Report of the Chief

of the

Bureau of Entomology and Plant Quarantine

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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration

REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE, AGRICULTURAL RESEARCH ADMINISTRATION, 1947

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 15, 1947.

MR. W. V. LAMBERT,
Agricultural Research Administrator.

DEAR MR. LAMBERT: I submit herewith a report of the work of the Bureau of Entomology and Plant Quarantine for the fiscal year ended June 30, 1947.

Sincerely yours,

P. N. ANNAND, *Chief.*

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INTRODUCTION

Again this year research activities centered largely around determining the value of new chemicals that show promise for possible use as insecticides and improving methods of applying insecticides. Various formulations of DDT were given further extensive tests under field conditions against a wide variety of pests, and several of the newer materials were subjected to laboratory and field tests, particularly in comparison with DDT or the standard insecticides that have long been in use.

Little is yet known regarding the toxicology of the newer insecticides. Therefore, recommendations for their use have not been made, except for DDT in a few instances. The principal problem relative to the use of DDT in agriculture is still the possible hazardous effect on man and animals of residues remaining on food and forage crops. Until more definite information is obtained on the accumulations of such DDT residues in milk and meat, the Bureau does not recommend that plants or portions thereof treated with DDT be fed to livestock. Even less information is yet available concerning the harmful effects of some of the newer materials that are showing considerable promise as insecticides, and further study is under way to determine the effects of continued applications of all these new materials on soils.

Progress was made during the year in a number of large-scale insect and plant-disease control programs carried on in cooperation with State and other agencies. The use of new and improved materials, methods, and equipment aided greatly in this field of endeavor, and made possible some additional modifications in treatments required for certification of materials to permit movement under plant quarantine regulations. Several major changes were also made in plant quarantine regulations.

Some important administrative changes were made during the year. The laboratory maintained by the Division of Foreign Parasite Introduction at Montevideo, Uruguay, for conducting investigations of beneficial insects in South America was closed in December 1946. The laboratory for conducting similar investigations in Europe, which was closed during the war, was reopened at St. Cloud, France, in January 1947. The field work of the Division of Insects Affecting Man and Animals was reorganized, so that investigations are now centered at only four laboratories, located at Orlando, Fla., Kerrville, Tex., Savannah, Ga., and Corvallis, Oreg. Herbert L. Haller, formerly assistant leader of the Division of Insecticide Investigations, was appointed Assistant to the Chief of Bureau on March 13, 1947, to coordinate the chemical work of the Bureau and maintain contacts with the chemical industry. Edward F. Knipling was appointed leader of the Division of Insects Affecting Man and Animals on September 15, 1946, succeeding Emory C. Cushing, who resigned from Government service. John M. Corliss was placed in charge of the Division of Gypsy Moth Control on March 15, 1947, replacing Ralph A. Sheals, who resigned to enter private industry.

Unless otherwise specified, references to the year 1947 in this report refer to the fiscal year.

RESEARCH INVESTIGATIONS

NEW INSECTICIDES TESTED EXTENSIVELY AGAINST MANY KINDS OF INSECTS

During the year DDT was widely used for the control of household insects, pests on livestock, defoliating and other insects in forest areas, and insect pests on a wide variety of agricultural crops. Many problems still remain, however, regarding the use of this material, especially in agriculture. Extensive experimental work has been continued to determine the most suitable formulations and schedules for use on various crops against different insects, and a few additional recommendations have been made. The question of possible hazardous effect on man and animals of residues of DDT on food and forage crops is still of great importance, as is also the problem of whether or not accumulations of the material in soils, resulting from continued application to crops, may prove harmful. It has now been found that, when feed or forage bearing DDT residues is fed to animals, DDT may be excreted in the milk and accumulated in the fat of the animals.

A number of newer organic materials were tested extensively during the year and showed much promise. They included benzene hexachloride, chlordane (previously designated as 1068), and a chlorinated camphene, all of which were mentioned briefly in last year's report, and the still newer materials hexaethyl tetraphosphate and tetraethyl pyrophosphate. Present experimental evidence indicates that some of these compounds are highly effective against pests not controlled by DDT and that some give even more effective control of certain pests against which DDT has shown considerable promise. In almost no instance has it been possible to recommend the use of these newer materials, for even less is known regarding their toxicological effects than is known of those of DDT.

PROGRESS MADE IN STUDIES OF CHEMICAL PROBLEMS

Chemical investigations on insecticides and fungicides were directed during the year mainly toward the control of agricultural pests, although some work was continued on the insecticide problems encountered by the Army and the United States Public Health Service.

Several problems pertaining to DDT insecticides were given attention by the chemists. They continued developmental work on formulations for use in sprays, dusts, and aerosols. Standard analytical procedures for the determination of DDT in dusts and sprays were established and have been adopted by the Association of Official Agricultural Chemists. It was determined, by analyses for labile and total chlorine, that the weathering of DDT deposits on apples from several types of spray and dust formulations does not result in any accumulation of decomposition products. Studies are under way to determine the effect of various solvents on the decomposition of DDT by ultraviolet light.

Analyses of milk, butter, lean meat, fat, and various organs from cattle receiving feed treated with DDT indicate that the DDT is concentrated mainly in the fat of the animals, with relatively small amounts in the lean meat. DDT appeared in the milk, dissolved in the butterfat. In cooperative tests with the Bureau of Animal Industry,

swine were fed meat from cattle that had been on a diet of hay treated with DDT. The fat of the swine after 6 weeks' feeding contained about 11 to 18 p. p. m. of DDT. Analysis of several kinds of vegetables taken from plots that had been dusted or sprayed with DDT did not indicate any absorption of the DDT into the edible tissues.

It was found that 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane, or TDE, is converted to an isomeric compound, meso-4,4′-tetrachlorobibenzyl, when heated with ferric chloride. This reaction might find application in the analysis of mixtures of DDT and TDE.

A sample of a technical grade of the fluorine analog of DDT, 1-trichloro-2,2-bis(*p*-fluorophenyl)ethane, was purified by repeated crystallization. Both the technical product and the pure compound were prepared and submitted to entomologists for testing against several species of insects.

Samples of the pure alpha, beta, gamma, and delta isomers of benzene hexachloride were supplied for laboratory tests against a number of kinds of insects. The chemical compatibility of benzene hexachloride with other insecticides, fungicides, and accessory materials received some study. In cooperation with other Government agencies and producers of benzene hexachloride, analytical methods that have been proposed for this insecticide, and especially for its principal active constituent, the gamma isomer, are being investigated. A cryoscopic, or freezing-point, method is being developed which shows promise for the determination of the gamma isomer. At present there is no method for the determination of this isomer by means available to the ordinary analytical laboratory.

A chemical study was made of hexaethyl tetraphosphate. It was shown that the commercial product is a mixture, rather than a single compound. Because it is quickly hydrolyzed in the presence of water to nontoxic products, the course of the hydrolysis was investigated chemically. Several compounds were prepared by the reaction of different molecular proportions of phosphorus pentoxide and triethyl phosphate. When these compounds were tested against crysanthemum aphids, pentaethyl tripolyphosphate was as toxic as hexaethyl tetraphosphate. Analogs of hexaethyl tetraphosphate containing other alkyl groups were prepared for entomological tests.

Different procedures for making tetraethyl pyrophosphate were investigated, and it was found that two different products were obtained, depending upon the method of preparation. One product is decomposed upon distillation *in vacuo*, while the other is distillable and is much the more toxic to insects. Two simple tests have been devised for distinguishing distillable from nondistillable tetraethyl pyrophosphate.

Further studies were made of insecticides derived from plants. In this work progress was made toward the synthesis of the cinerins, insecticidal compounds occurring with the pyrethrins in pyrethrum flowers, in that dihydrocinerolone was synthesized. This work necessitated a slight correction in the structural formula previously proposed for cinerolone, the alcoholic component of the cinerins, which are esters of cinerolone with the pyrethrum carboxylic acids. Storage tests are being made on pyrethrum extracts containing 20 percent of pyrethrins, in order to obtain information for use in the stock-piling of the extracts by the Government. Samples are stored under ordinary

and low-temperature conditions, with and without an antioxidant, and chemical and biological tests are made at intervals.

The chemical investigations also included X-ray diffraction studies of samples of pyrophyllites, talcs, and clays used as diluents for insecticide dusts. Each of these minerals was found to vary greatly in purity, especially in quartz content, according to its origin. Some clays and carbon blacks were examined with an electron microscope to determine their approximate particle size, type of agglomerates, and similar properties.

About 2,200 samples of insecticides and residues were analyzed by Bureau chemists during the year at the request of the various Divisions of the Bureau. Several hundred samples of pyrethrum flowers imported by the Reconstruction Finance Corporation were analyzed, as well as samples of concentrated pyrethrum extracts supplied to the Government for stock-piling by the Army-Navy Munitions Board.

MANY NEW MATERIALS GIVEN BIOLOGICAL TESTS

A large number of materials were tested in a preliminary way in the laboratory against various insects to ascertain whether or not they had insecticidal value.

A total of 137 new chemical compounds, both synthetic and of plant origin, were tested against adult houseflies, and 32 against the larvae, but none were found to be sufficiently toxic to warrant further study. Out of 117 compounds tested on plant-feeding insects, 21 showed sufficient toxicity to warrant further investigation.

In a search for synergists for pyrethrum, 101 synthetic compounds were tested on flies and cockroaches. None of these were found to be of appreciable value for this purpose. Two commercial materials, piperonyl cyclonene and piperonyl butoxide, showed considerable promise, one in tests against houseflies and the other against cockroaches. In work done in cooperation with the Eastern Regional Laboratory of the Bureau of Agricultural and Industrial Chemistry, phthalonitrile and diphenyl sulfide were found to have marked synergistic effect when used with nicotine against plant-feeding insects.

The gamma isomer of benzene hexachloride was found in laboratory tests to be much more toxic to insects than the alpha, beta, and delta isomers. It proved to be more toxic than DDT to 8 out of 10 leaf-feeding insects.

Two new insecticides, one containing chlordane and the other a chlorinated camphene, were tested further against various insect pests, and both were found to exhibit the selectivity in action that is characteristic of organic compounds. Both were more effective than DDT against certain insects and less so against others. Chlordane was exceptionally effective against cockroaches.

RESULTS OF TESTS AGAINST TRUCK-CROP AND GARDEN INSECTS

The work concerning truck-crop and garden insects has dealt primarily with research on the newer insecticides for the control of the pea aphid, the pea weevil, caterpillars that attack cabbage, *Lygus* bugs affecting beet-seed production, onion thrips as a pest of onions grown for seed and culinary purposes, aphids and flea beetles affecting potatoes, and wireworms injuring vegetable crops, particularly beans in California and miscellaneous vegetables, including potatoes, in Wash-

ington. Studies have been continued on the control of insects affecting tobacco, with particular emphasis on the development of more effective insecticides for use against these insects. Investigations on insects affecting greenhouse plants and mushrooms, which were discontinued during the war years, were resumed as funds were made available. An investigation of the control of the pea aphid on peas grown for processing in Washington and Oregon was initiated, and attention was directed toward the successful application of insecticides from the air. Ground machines applying dusts, sprays, and aerosols, both gas- and smoke-propelled, were also utilized. Special effort was made to develop an insecticidal treatment for beans grown for seed in southern Idaho to protect them from leafhoppers transmitting curly top disease.

In cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, studies were initiated on the effect of DDT and benzene hexachloride in the soil on plant growth. The objective was to determine the effect of accumulations of these insecticides on crop growth when the material was applied for the control of soil-infesting pests or those attacking the foliage of the crop. In the Yakima Valley the emphasis on the work with potato insects was shifted from the control of the flea beetle to biology and control of aphids affecting potatoes.

The results obtained with various new insecticidal materials and new formulations of DDT against truck-crop and garden pests are summarized below.

Hexaethyl tetraphosphate was found to be a good substitute for nicotine sulfate in the control of the cabbage aphid. In freshly mixed dusts, sprays, or aerosols it is more effective than nicotine sulfate against some species of aphids, and can be used at lower temperatures and in the presence of higher wind velocities. Hexaethyl tetraphosphate is also useful in controlling the turnip aphid and the green-peach aphid, and is promising for the control of the pea aphid and the two-spotted spider mite. Early in 1947 a related compound, tetraethyl pyrophosphate, was found to be even more toxic to the cabbage aphid. Benzene hexachloride was also effective against aphids, particularly the cabbage aphid, the turnip aphid, and the green peach aphid. In limited tests a chlorinated camphene was toxic to the turnip aphid.

An improved method was developed for controlling mixed infestations of seven species of caterpillars that attack cabbage. This method involves the use of DDT before the heads begin to form and of rotenone during the heading period, so that arsenical and fluorine compounds become unnecessary. Before DDT was introduced, several different materials had to be used, depending upon the species of caterpillars present. The effectiveness of DDT dust was found to be increased by the inclusion of either mineral oil or sulfur. Benzene hexachloride and the methoxy analog of DDT gave promising results in preliminary tests against cabbage caterpillars. The odor of benzene hexachloride will limit its use on vegetable crops.

Against insects attacking beans a dust containing DDT, rotenone, and sulfur was found to be an effective all-purpose treatment. This mixture controlled the Mexican bean beetle and powdery mildew disease, as well as the corn earworm, which causes considerable damage to the fall crop of beans near Norfolk, Va. The use of DDT on snap

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beans for corn earworm control after the pods begin to form may involve a residue hazard. Hexaethyl tetraphosphate, a chlorinated camphene, the methoxy analog of DDT, and a mixture of pyrethrum and piperonyl cyclonene gave promising results against the Mexican bean beetle, whereas *Ryania* powder, sabadilla, zinc nicotinyl fluosilicate, chlordane, benzene, hexachloride, and DDT were relatively ineffective.

For the control of onion thrips on onions grown for seed and for culinary purposes, DDT gave equally as good results as nicotine and tartar emetic. Benzene hexachloride and a chlorinated camphene also gave promising results against this thrips.

For the control of the pea weevil and the pea aphid, DDT continued to give more satisfactory results than rotenone or any other insecticide. Its use can be recommended provided the pea vines are not fed to livestock. In limited tests two compounds related to DDT, TDE and the methoxy analog, and benzene hexachloride gave promising results against the pea weevil.

DDT continued to give control of potato insects. Research on DDT formulations developed by the Bureau resulted in a saving of more than $300,000 in insecticide cost during 1946 to potato growers in Maine, where DDT was used on 85 percent of the 219,000-acre crop for control of aphids. Experiments demonstrated that yields can be increased by beginning applications before appreciable infestations of aphids are present. Studies on the tuber flea beetle in Washington showed that this pest of potatoes passes the winter principally in the soil and is not killed by burial in the soil or by removal of debris. In preliminary tests DDT when mixed with the soil killed some of the flea beetle larvae. Both DDT and benzene hexachloride are toxic to the flea beetles feeding on the foliage.

The herbicide 2,4-D was found to be very effective in killing wild host plants of the sweetpotato weevil and volunteer sweetpotato plants. DDT dust and sprays were found to be useful in killing the weevil in storages but not in protecting the sweetpotato plants from the insect.

For the tomato insects DDT mixed with sulfur continued to be more effective than other insecticides. Benzene hexachloride, chlordane, and TDE were found to be less toxic than DDT to the tomato fruitworm in California.

Experiments in Washington and California on the control of wireworms in irrigated land showed ethylene dibromide to be the most effective of the soil fumigants for use at soil temperatures above 50° F. D-D mixture (a mixture of 1,2-dichloropropane and 1,3-dichloropropylene) is less toxic to wireworms, but may be used effectively at temperatures as low as 40° and has the advantage of being useful against nematodes. 1,1-Dichloro-1-nitroethane ranges in toxicity between ethylene dibromide and D-D mixture, but is effective at soil temperatures near freezing. DDT was found to retain its toxicity to wireworms in the soil for at least 3 years, but to kill very slowly. Except for the soil fumigants, DDT seems to be the most promising soil insecticide for the control of wireworms in irrigated lands. At dosages of DDT required to kill wireworms no damage to plants was reported. Benzene hexachloride was found to be extremely toxic to wireworms and to kill more rapidly than DDT, but there were indications that it may have a more deleterious effect on plant growth than DDT ap-

plications. In limited tests chlorinated camphene, chlordane, and the methoxy analog of DDT were also toxic to wireworms.

DDT was found to control the tobacco budworm, when other methods become ineffective after the plants either form seed heads or are topped. This insecticide controlled the tomato hornworm on tobacco, but was not satisfactory at practical dosages against the tobacco hornworm, often found on tobacco in association with the tomato hornworm, particularly in the flue-cured areas.

In laboratory tests benzene hexachloride and chlorinated camphene were found to be very toxic to the tobacco hornworm, being about 10 times as toxic as DDT. Although in recent years several hundred organic compounds have been tested against this insect, these two materials are the first to show outstanding toxicity.

D-D mixture applied for green June beetle control before seeding was found to cause slight stunting of tobacco plants in some seedbeds in which the soil was not stirred and aerated well after application. Progress was made in determining a safe and effective application schedule for controlling the green June beetle. Ethylene dibromide also proved to be an effective fumigant for the insect.

In laboratory tests chlordane and benzene hexachloride sprays were found to be toxic to the tobacco moth and the cigarette beetle. The disagreeable odor of benzene hexachloride precludes its use on stored tobacco, but chlordane did not appear to affect adversely the quality or aroma of the tobacco and should be tested under warehouse conditions. DDT spray residues were found to be toxic to the tobacco moth for 8½ months, and this spray gave promising results under warehouse conditions. Pyrethrum-oil sprays continued to give control of the tobacco moth under open storage conditions, and when applied at intervals throughout the summer had no injurious effect on the taste, aroma, appearance, or smoking quality of the tobacco. Pyrethrum-dichlorodifluoromethane aerosols in laboratory tests were toxic to the tobacco moth but not to the cigarette beetle, and did not adversely affect flue-cured tobacco. The cigarette beetle and the tobacco moth were found to be highly resistant to greatly reduced air pressures. Progress was made in the development of a dosage schedule for fumigation with acrylonitrile mixed with equal parts of carbon tetrachloride. This fumigant penetrated more deeply into hogsheads of tobacco than did hydrocyanic acid gas and did not have any undesirable effect on the tobacco. Although a higher dosage is required than with hydrocyanic acid gas, fumigation with this material is cheaper and is less dangerous to the operator.

DDT continued to be more effective than pyrethrum in the commercial control of *Lygus* bugs on sugar beets grown for seed. A single application of DDT during the prebloom stage of plant development was found to be sufficient. Benzene hexachloride was more toxic than DDT to the Say stinkbug and the green peach aphid on sugar beets, but was less satisfactory than DDT for *Lygus* bugs. Chlordane and a chlorinated camphene were toxic to *Lygus* bugs but were not very toxic to the Say stinkbug.

Progress was made in developing methods for controlling the beet leafhopper with DDT emulsions. These emulsions are very toxic to the leafhopper, but their use has not reduced appreciably the spread of the curly top disease on sugar beets. DDT was found to be more toxic to the leafhopper than benzene hexachloride, the methoxy analog

of DDT, hexaethyl tetraphosphate, hydroxymethylflavan, chlorinated camphene, or chlordane.

In investigations on insects affecting greenhouse plants and mushrooms, which were reopened on July 1, 1946, emphasis was placed on application of new insecticides in aerosol form. DDT, hexaethyl tetraphosphate, and tetraethyl pyrophosphate gave outstanding results in the control of certain greenhouse pests. Aerosols containing hexaethyl tetraphosphate have given unprecedented control of the two-spotted spider mite in commercial tests on roses. Weekly applications of this aerosol in rose houses over a period of 4 months resulted in a vigorous growth free of spider mites and their injury. The stems of the roses were longer and the production in some houses increased 30 percent. Experiments indicate that four applications at 3-day intervals are sufficient to give almost complete control of the pest. DDT aerosols have proved effective against thrips on roses and other greenhouse plants.

NEW MATERIALS SHOW PROMISE AGAINST INSECTS AFFECTING CEREAL AND FORAGE CROPS AND SUGARCANE

Further investigations with DDT for the control of cereal, forage, and sugarcane insects did not materially alter its status from that determined in the 1945 season. DDT was found to be too ineffective for practical use against the sugarcane borer, grasshoppers, and white grubs. Substantial progress was made in developing suitable methods of using DDT against the European corn borer, the corn earworm, insects attacking legume crops grown for seed, white-fringed beetles, and insects attacking stored grain or cereal products. The major limitation to the use of DDT on cereal and forage crops, however, continues to be the possible poison hazards to man or animals of residues remaining on treated crops or grains. Until these hazards are better understood, any recommendations for the use of DDT against cereal and forage insects must be qualified. Insects against which it is now recommended with the precaution that the treated crops should not be fed to livestock are *Lygus* bugs, the alfalfa weevil, and other insects attacking seed alfalfa; the vetch bruchid attacking hairy vetch; insects attacking seed stocks in storage and inhabiting walls and woodwork of grain bins, mills, and warehouses; and the European corn borer attacking corn from which only the husked ears or shelled grain is to be utilized for food or feed. For treatment of seed stocks DDT was found to be compatible with all the common fungicides except those containing ethyl mercury phosphate, so that the use of a combined insecticidal and fungicidal dust now becomes feasible.

A number of other new compounds were tested against this group of insects during the year. Although favorable results were obtained with some of them, any recommendations on their practical use would, for the present at least, have to be qualified by the precaution concerning residue hazards that has been given for DDT.

In general, benzene hexachloride has not been found so effective against cereal and forage insects as have some of the other new insecticides. It is outstanding, however, in soil applications for control of newly hatched white-fringed beetle larvae, and is very toxic to the adults of these insects when applied either to the foliage or directly to the beetles. It also shows much promise for control of the sugarcane borer and the sugarcane aphid and for mixing with seed stocks to

protect them against stored-grain insects. When applied to alfalfa as a dust or spray to kill grasshoppers, benzene hexachloride gave erratic results. Initial kills were fair to good, but this material ceased to be effective within a very few days. Although toxic to *Lygus* bugs, the corn earworm, the European corn borer, the potato-leaf-hopper, and the chinch bug, it was less effective than DDT against these insects.

Chlorinated camphene has as yet been tested against cereal and forage insects in only a preliminary way. It showed some promise against grasshoppers, the European corn borer, the sugarcane borer, the yellow sugarcane aphid, white-fringed beetles, and several stored-grain insects; was fairly effective against *Lygus* bugs, the corn earworm, and the chinch bug; and was comparatively ineffective against white grubs.

Chlordane, another chlorinated hydrocarbon, is one of the most promising insecticides yet found for control of grasshoppers when directly applied to heavy vegetation such as alfalfa or weeds along irrigation ditches. It also appears to be very effective against the corn earworm and the white-fringed beetle, and as a contact insecticide against some stored-grain insects. It has not shown promise for control of the sugarcane borer.

In preliminary tests of other organic compounds, certain formulations of the methoxy analog of DDT were lethal to the European corn borer and flour beetles and fairly effective against *Lygus* bugs. This material showed little promise against the corn earworm, grasshoppers, white-fringed beetles, the chinch bug, and the sugarcane borer. TDE, another compound related to DDT, was very effective against the European corn borer and against stored-grain insects in farm bins, but only moderately so against the vetch bruchid. Hexaethyl tetraphosphate killed a high percentage of grasshoppers in one field test, but severely injured alfalfa foliage. Two commercial products, piperonyl cyclonene and piperonyl butoxide, were relatively ineffective against flour beetles and the European corn borer, although one of these when added to pyrethrum was highly effective against flour beetles and the corn earworm, and fairly effective against *Lygus* bugs. Ammonium fluosilicate was found to be a very promising substitute for sodium fluosilicate in grasshopper baits, and aluminum fluoride compared favorably with cryolite in preliminary tests against first-generation sugarcane borers in Louisiana.

In laboratory tests of insecticides derived from plants, a sabadilla concentrate containing 2 percent of veratrine alkaloids was highly effective against newly hatched larvae of the European corn borer. In the field sabadilla was also found to be very effective against chinch bugs, of less value against grasshoppers and *Lygus* bugs, and comparatively ineffective against the corn earworm and the sugarcane borer. Ground stems of *Ryania speciosa* continued to provide good protection from the European corn borer, and this material has been recommended to growers. In preliminary field tests it was also very effective against the sugarcane borer, somewhat less effective against the fall armyworm, and of little value against the chinch bug.

Several inert dusts were tested against stored-grain insects. Attapulgus clay, bentonite, silica gels, and diatomaceous earth gave good to excellent protection of stored seeds, pelleted and ground animal feeds, and powdered hand soap when they contained not more than 12 percent of moisture. Magnesium oxide powders protected stored seed stocks from the rice weevil and the confused flour beetle,

but the activated powders were no more effective than nonactivated powders.

Preliminary observations indicate that local application of fumigants to individual machines in flour mills can be dispensed with, if the entire dosage is fed into the flour stream at the breaker rolls with the machinery running a few minutes before the mill is shut down. Not only do results appear to be as good as when individual machines are treated, but the time required for the operation is reduced from several hours to a few minutes.

In tests of new fumigants, the gamma isomer of methallyl chloride was three times as toxic to the confused flour beetle as the alpha isomer, and a mixture of 1 part of chloroethyl formate and 3 parts of carbon tetrachloride gave good results against the rice weevil and the flour beetle at slightly less than 1 gallon per 1,000 bushels.

Although fumigation of farm bins is much more expensive than treatment of interior walls with toxicants, it has been found to be a more efficient means of controlling insects attacking farm-stored grain.

FRUIT INSECT CONTROL BOTH AIDED AND COMPLICATED BY USE OF NEW MATERIALS

Against a number of important fruit insects DDT has continued to give results closely similar to those reported a year earlier. Growers throughout the country used DDT for control of the codling moth in 1946 with outstanding success, although the credit must be shared with weather conditions unfavorable to the codling moth. Tests at Vincennes, Ind., indicated that the shape of DDT particles does not influence their effectiveness and that the optimum particle size lies between 2½ and 5 microns. DDT solutions applied in atomized form with blower equipment generally caused injury to the trees, but emulsions showed much promise. It was also shown that deposits of DDT, even when 10 days old, are toxic to the moths and reduce egg laying.

Coincident with the use of DDT in apple orchards for codling moth control, various species of orchard mites and the woolly apple aphid have increased greatly in numbers and threatened or caused serious injury each year. In 1946 another pest of little importance for many years, the red-banded leaf roller, became sufficiently numerous to cause more injury than the codling moth in certain middle-western and eastern orchards. It is believed that nicotine sulfate can be relied upon to control the woolly apple aphid, and lead arsenate to control the red-banded leaf roller, but a fully satisfactory treatment for orchard mites is still not available. Dormant oil gives a high degree of control of the overwintering eggs of the European red mite and delays the build-up of a serious summer infestation for several weeks, but has little effect on other species of orchard mites. Summer oil and certain dinitro aromatic compounds have been found superior to other materials as acaricides for use during the growing season, but they are not fully satisfactory under all conditions.

In the Pacific Northwest DDT-xanthone combinations again held mite populations to a low level when used in five or six applications, but xanthone is not a reliable acaricide unless used in a full-season program of four or more cover sprays. Hexaethyl tetraphosphate and related compounds showed promise in mite control in preliminary laboratory tests at Beltsville, Md., and in late-season small-scale field

tests at Vincennes, Ind., and Yakima, Wash. Since these materials are not effective against mite eggs, more than one application would be required to give control under orchard conditions. Laboratory tests at Beltsville, Md., and field tests at Yakima, Wash., indicate that these materials may also be effective against aphids. A chlorinated camphene was found ineffective as an acaricide in laboratory tests.

At Vincennes, Ind., DDT sprays and dusts applied to peach trees 2 days after the full-bloom period reduced from 10 to 2 the percentage of deformed peaches caused by sucking bugs. Similar results were reported from South Carolina a year ago.

DDT again gave considerable control of the fruit-infesting broods of the oriental fruit moth. In New Jersey one application shortly before harvest reduced worm injury to fruit by 50 to 80 percent, and DDT residues on the harvested fruit were not objectionable. In Ohio, under conditions of moderate infestation, ripe-fruit injury in Elberta peaches was reduced to approximately 5 percent by two applications of DDT, 1 pound per 100 gallons of spray. Residue analyses indicated that DDT should not be applied to peach trees later than 3 weeks prior to harvest if excess residues on the fruit are to be avoided.

In preliminary tests at Yakima, Wash., DDT, 1 pound in 100 gallons, appeared to control shot-hole borers in cherry trees, and at Poughkeepsie, N. Y., two applications reduced leaf infestations of the cherry leaf miner (*Profenusa canadensis* Marl.) from 45 percent to 9 percent.

In Georgia two applications of DDT, 3 pounds per 100 gallons, reduced weevil infestation in pecan nuts from 43 percent to 1 percent, but in central Texas DDT was less effective. The chestnut weevil also appeared to be susceptible to control with DDT, three applications at 2 pounds per 100 gallons reducing weevil-injured nuts at harvest by 90 percent. DDT also showed promise for use against other pecan insects, but was not very effective against the hickory shuckworm.

At Fort Valley, Ga., cage and orchard tests indicated that benzene hexachloride may have value for controlling the plum curculio on peaches, and that the minimum effective concentration is close to 1 pound of technical benzene hexachloride (gamma isomer 10 percent) per 100 gallons of spray. This strength did not affect fruit flavor noticeably when applied according to the regular spray schedule. The same quantity in combination with oil, or twice that quantity alone, affected fruit flavor adversely when applied 4 weeks prior to harvest. Otherwise no injury resulted to fruit, trees, or foliage. Benzene hexachloride also showed considerable promise for the treatment of infested peach drops to destroy the grubs of the curculio in them.

In Louisiana 4 pounds of a wettable benzene hexachloride (gamma isomer 5.75 percent) per 100 gallons was as effective as the nicotine sulfate-oil spray against the black pecan aphid and reduced hickory shoot curculio (*Conotrachelus pecanae* Buch.) infestations by about 65 percent, a much greater reduction than was effected by DDT or lead arsenate. Benzene hexachloride was also toxic to the woolly apple aphid at Yakima, Wash. Against the Japanese beetle in New Jersey benzene hexachloride was found to have insufficient lasting power to compete with DDT for use against either the adult beetles on plants or the grubs in the soil, although it exhibited high initial toxicity to both forms.

Benzene hexachloride also showed promise as a spray against pear psylla nymphs and the cherry leaf miner in New York, shot-hole borers in Washington, and as a soil treatment against nitidulid beetles in date gardens in California. It may impart an objectionable flavor to pears if used in midseason or later. It was less effective than DDT against sucking bugs that cause deformed peaches, the nut casebearer on pecans in Florida and Texas, and the little fire ant in citrus groves in Florida. It was comparatively ineffective against the hickory shuckworm, the pecan weevil, the codling moth, the peach-tree borer, and orchard mites.

Chlordane gave favorable results when applied as a dust against the pear thrips on prunes, but was comparatively ineffective as a spray against the codling moth under orchard conditions and against mites in the laboratory. As a soil treatment it showed promise against Japanese beetle grubs but not against those of the European chafer (*Amphimallon majalis* Razoumowsky).

Several of the other new materials were tested in a preliminary way against various pests of fruit. The methoxy analog of DDT gave a high degree of control of the codling moth in Washington, Indiana, and West Virginia, and of the Japanese beetle in New Jersey, but was less effective against both insects than DDT and did not hold orchard mites in check. This material was not promising against the oriental fruit moth in either New Jersey or Ohio. O, O-diethyl O, *p*-nitrophenyl thiophosphate showed promise in preliminary tests against the pear thrips on prunes and against the pear psylla. *Ryania* extract again gave good control of the codling moth in the East under conditions of light infestation.

In Mexico derris or cube dust in soluble or emulsive spray oils gave very high mortality of the citrus blackfly on citrus. A formula for the control of the insect was given to the Mexican authorities. A heavy infestation of the blackfly now occurs near Valles on the international highway about half way between Veracruz and the Rio Grande Valley. Spray demonstrations with the formula were made near Valles in cooperation with the Mexican authorities, who propose its first use there.

NEW INSECTICIDES OF MUCH INTEREST IN CONTROL OF COTTON INSECTS

Several of the new organic insecticides and their combinations have been tested extensively against cotton insects at 11 Bureau laboratories located in 6 of the 19 cotton-growing States. This work is carried on in cooperation with State agricultural experiment stations and with other Federal, State, and local agencies. Results thus far have been promising, and interest in the new insecticides is increasing. The Bureau considers that their use is still in the experimental stage, and they are not yet recommended as substitutes for calcium arsenate, sulfur, nicotine, DDT, and other standard insecticides commonly used on cotton.

Benzene hexachloride has now been tested for 2 years in the laboratory and under field conditions against the major cotton insect pests. Field experiments conducted during 1946 in South Carolina, Mississippi, Louisiana, and Texas showed that dusts containing approximately 5 percent of the gamma isomer gave satisfactory control of the boll weevil and the cotton aphid but were ineffective against the bollworm. In early season presquare experiments at Tallulah, La.,

a 90-percent reduction in weevil population was noted 24 hours after application. In similar experiments at Waco, Tex., the reduction averaged 80 percent in plots treated with benzene hexachloride containing 5.75 percent of the gamma isomer, and 70 percent in plots treated with 2.88 percent of the gamma isomer. Later in the season a 2.88-percent-gamma dust was equal to calcium arsenate in controlling boll weevils, but a 1.44-percent-gamma dust was less effective. Satisfactory control of the cotton leaf worm, the cotton flea hopper, and other hemipterous insects was obtained at all concentrations.

At Stoneville, Miss., benzene hexachloride containing 5 percent of the gamma isomer gave satisfactory results when applied to cotton by airplane at the rate of 10 pounds per acre-application for cotton aphid control. In another experiment a dust containing 2.5 percent of gamma-benzene hexachloride was applied by airplane at the rate of 14 pounds per acre for cotton leaf worm control, with satisfactory results. The dust was applied September 24, at a time when eggs and first- and second-instar larvae were present on the plants in large numbers. Eggs of the leaf worm continued to hatch, indicating that this dosage of benzene hexachloride had no ovicidal effect. However, no subsequent infestation developed, indicating sufficient residual toxicity to control the young larvae. This dust also proved to be a very efficient remedy for aphid control.

At Waco, Tex., a mixture of 5-percent DDT and benzene hexachloride containing approximately 3 percent of the gamma isomer gave outstanding control of heavy infestations of bollworms, cotton aphids, boll weevils, and cotton leaf worms. Benzene hexachloride, alone or mixed with DDT, also controlled the cotton flea hopper, the tarnished and rapid plant bugs, thrips, loopers, stinkbugs, garden webworms, and fall armyworms. These benzene hexachloride mixtures gave a much quicker kill of the boll weevil and longer protection against the cotton leaf worm than did calcium arsenate.

Benzene hexachloride has a disagreeable odor, and under certain conditions has caused skin and eye irritation to the operator and leaf burn to the cotton. In no instance, however, has economic injury to the cotton plant been reported from its use. The following diluents have been used satisfactorily with benzene hexachloride: Sulfur, pyrophyllite, talc, and clays. The sulfur aids in reducing red spider damage. Field experiments thus far indicate that benzene hexachloride should not be mixed and dusted with lime or standard calcium arsenate.

In laboratory screening tests at Waco, Tex., the new synthetic insecticide known as chlorinated camphene gave promising results against the bollworm, boll weevil, cotton leaf worm, cotton aphid, cotton flea hopper, southern green stinkbug, cabbage looper, and garden webworm. In two field experiments a 20-percent concentration gave excellent control of comparatively heavy infestations of bollworm, boll weevil, cotton aphid, and cotton leaf worm. Complete control of aphids was obtained from chlorinated camphene, whereas adjoining cotton dusted with calcium arsenate shed approximately 50 percent of its leaves from aphid damage. In field experiments the average gain in yield of cotton from the use of chlorinated camphene over that in comparable untreated fields was 569 pounds of seed cotton per acre, or 235 percent. An average of 46 percent more cotton was

produced in plots where chlorinated camphene was used than in those treated with calcium arsenate.

In field-plot experiments with DDT dust and spray formulations for pink bollworm control, the degree of control increased with the quantity of DDT used per acre. Reductions were approximately 52, 62, and 72 percent from applications of 7, 12, and 17 pounds, respectively, per acre. Emulsion sprays gave about the same control as dusts when tested under the same conditions of light rainfall, the dusts giving better plant coverage and the sprays better adherence. Biweekly applications of 3 pounds of technical DDT per acre gave the same control as weekly applications of 1½ pounds in tests conducted with both spray and dust formulations.

In large-scale field experiments from five to nine applications of 10-percent DDT dust applied at weekly intervals by airplane at the rate of 16 pounds per acre gave an average reduction of 58 percent in the pink bollworm infestation and an average gain of 259 pounds of seed cotton per acre, but did not eliminate all the pink bollworm damage.

In laboratory and cage tests at Waco, Tex., chlordane gave promising results against cotton aphids, cotton flea hoppers, southern green stinkbugs, and garden webworms. Chlordane was more effective than chlorinated camphene against the boll weevil, but not so effective as benzene hexachloride. It was only slightly effective against the bollworm.

In tests at Florence, S. C., hexaethyl tetraphosphate gave 100 percent control of the two-spotted spider mite adults and nymphs on cotton in a greenhouse, when applied as a spray at strengths of 1 pound per 100, 150, and 200 gallons. No ovicidal action resulted from any of these strengths, and reinfestations occurred within a few days. Cotton that received these sprays was injured seriously. At Waco, Tex., dusts containing hexaethyl tetraphosphate were effective against cotton aphids but not against boll weevils and bollworms. These dusts rapidly break down in storage. Dust mixtures 1 day old lost much of their effectiveness, and those 3 or 4 days old were completely ineffective. Hexaethyl tetraphosphate appears to be incompatible with lime or calcium arsenate, since fresh mixtures with these materials were ineffective.

A 50-percent *Ryania* dust tested at Florence, S. C., did not compare favorably with calcium arsenate in reducing bollweevil infestations, but held aphid populations to approximately half those resulting when calcium arsenate was used. In field plots in Arizona a 25-percent *Ryania* dust was only slightly effective against plant bugs and stinkbugs.

Sabadilla dust was effective against southern green stinkbugs and cotton flea hoppers in tests at Waco, Tex., but it was not effective against cotton aphids, cotton leaf worms, bollworms, and boll weevils.

In screening tests at Waco, Tex., piperonyl cyclonene and piperonyl butoxide added to pyrethrum dusts were slightly effective against cotton flea hoppers but not against bollworms, boll weevils, cotton aphids, and southern green stinkbugs.

Field-plot experiments were also conducted with new schedules for applying some of the standard materials used in cotton-insect control. Two percent of nicotine in alternate applications of calcium arsenate, 1 percent of nicotine in all applications of calcium arsenate,

and calcium arsenate plus separate applications of a 3-percent nicotine dust as needed were all equally effective for control of both boll weevils and cotton aphids. Early-morning and late-afternoon applications of nicotine-calcium arsenate mixtures gave significant increases in yield over calcium arsenate and untreated checks, late-afternoon applications being slightly more effective.

TESTS AGAINST INSECT PESTS OF FORESTS AND WOOD PRODUCTS

In limited field tests conducted in the Adirondacks of New York, oil solutions of DDT were found to be more effective in killing spruce budworm larvae than were suspensions or emulsions. The minimum amount of DDT required could not be accurately determined because of irregularity in the distribution of the budworm population. However, both one-fourth pound and 1 pound of DDT in 1 gallon of solution per acre gave satisfactory control in some instances. It is believed that a dosage of 1 pound of DDT per acre will be adequate for extensive control operations, provided equipment and application procedures can be improved to give more uniform spray coverage.

Tests of DDT and benzene hexachloride sprays for control of *Ips*, *Dendroctonus*, and *Scolytus* beetles in various species of pine, spruce, and fir have given very encouraging results. Indications are that these insecticides may have considerable value for destroying bark beetle broods under thin to medium-thick bark and that they can be used to prevent attack in green logs or living trees. The use of these materials, especially if they can be applied by airplane or mist blowers, may greatly lessen the present excessive cost of control operations.

In experiments with DDT sprays against the group of elm insects suspected of transmitting the elm virus disease organism, contact of the insects with sprayed foliage for even 10 to 15 minutes greatly reduced their feeding. Longer periods of contact prevented feeding and resulted in mortality. Sprayed trees in field plots showed great reduction in numbers of these insects, even in plots sprayed only once during the season.

In small-scale tests DDT emulsions were effective against elm bark beetles that transmit the Dutch elm disease. Greatly expanded tests are now under way in the field to determine the number of applications per season and the minimum dosage that will be necessary for practical protection.

The large-scale field spray tests with DDT against sucking insects that may transmit the virus causing phloem necrosis are being continued. This work is being done in cooperation with the New Jersey Department of Agriculture; Connecticut, Missouri, and Ohio agricultural experiment stations; and city officials in Columbus, Ohio, and Kansas City, Mo.

Wettable DDT powders proved unsatisfactory for use against the smaller European elm bark beetle. Some foliage injury also developed, especially on Asiatic elm.

A 1-percent solution of DDT in fuel oil killed developing broods of bark beetles in elm and prevented adult beetles from attacking green logs and developing new broods. One thorough application remained effective for an entire season.

In cooperation with other agencies, tests were conducted to determine the value of various treatments in protecting wood products from

attack by termites and other insects. The National Housing Agency supplied funds for testing the susceptibility to termites of new building materials, such as light wall paneling made of kraft-paper honeycomb impregnated with synthetic resin and covered with thin sheets of aluminum, fiberboard made from palmetto, and wall paneling made of pressed excelsior bonded with an inorganic cement. Termites attacked all these materials after short accelerated tests. Assistance was also given to the Federal Public Housing Authority in writing specifications for buildings that will be resistant to termites.

DDT and benzene hexachloride dusts are proving very effective against dry-wood termites infesting Army buildings at Key West, Fla. Ammunition boxes treated with the newest chemical wood preservatives are also under test. Chemical treatments for insulation of underground wire and cables in the Canal Zone have already given needed protection against termites.

In cooperation with the United States Army Corps of Engineers, 65,000 oak pallets (storage boxes and platforms) at the Granite City, Ill., depot were given a 3-minute dip in 5-percent pentachlorophenol to remedy and prevent attack by powder-post beetles. After over 35 years' search for a chemical to prevent ambrosia beetles from attacking green logs and lumber, workers in the Bureau have found a 0.4 to 0.8 percent gamma-isomer concentration of benzene hexachloride in fuel oil to give more than 90 percent protection for 2 to 4 months. This was better than the results obtained with even an 8-percent concentration of DDT and much better than with any of the chemicals tested in previous years.

RESULTS OF EXPERIMENTS AGAINST PESTS AFFECTING MAN

Extensive experiments have been continued to determine the effectiveness of DDT and the comparative value of some of the newer organic materials for controlling pests injurious to the health of man and otherwise annoying to him. These studies included the development of treatments for military as well as civilian use.

Observations have now been made for 2 years to determine the efficacy of DDT residual treatments for the control of *Anopheles pseudopunctipennis* Theob., a malaria-carrying mosquito. These tests, under way in several villages near Mexico City, are being conducted in cooperation with the Rockefeller Foundation and the Federal and State health departments of Mexico. A single spraying of all buildings has reduced populations of adult mosquitoes by approximately 99 percent for the mosquito season, which usually lasts 5 months, and larval populations in rice fields surrounding the villages by almost 90 percent. A decrease in the incidence of malaria among the natives is indicated, but further observations over a longer period will be required to determine the degree of malaria control that has been achieved.

The preflooding treatment with DDT for the control of mosquitoes, reported briefly in the last annual report, has continued to show promise. In 1946 several plots along the Columbia River in Oregon were treated with a DDT-oil solution at rates of 1 to 3 pounds of DDT per acre, and 9 months later, after the plots had been flooded twice, larvae of *Aedes vexans* (Meig.) and *A. lateralis* (Meig.) that hatched from the flooded soil were killed. Under laboratory conditions com-

plete kill of newly hatched larvae of these species resulted at dosages of DDT as low as 1 part to 3 billion parts of water. Ten times this dosage was required to kill third-stage larvae. DDT dusts applied on several small mosquito-breeding areas in salt marshes at the rate of 2 pounds of DDT per acre, before hatching occurred, controlled larvae of *A. taeniorhynchus* (Wied.) for an entire season.

Studies to determine the value of DDT for control of the lone star tick were carried out in cooperation with the Corps of Engineers, U. S. Army, on the Camp Bullis Army Reservation near San Antonio, Tex. This tick, which is exceedingly abundant on the reservation, transmits a rickettsial disease called Bullis fever. DDT applied as a dust or spray at the rate of 2 to 4 pounds per acre gave excellent control of the tick and prevented reinfestation of the treated areas for 1 month to 6 weeks. These results confirm those of earlier studies against the same tick in South Carolina.

Observations were continued to determine the effects of DDT residual treatments for the control of houseflies in dairy barns. In Georgia and Florida DDT thoroughly applied a year previously was still giving adequate control of flies in some treated barns. In Alaska also, fly populations around dairies were reduced in this way.

Preliminary tests were made to find out whether or not houseflies develop a tolerance to DDT. For over a year successive generations were exposed to near-lethal concentrations of DDT sprays. The progeny of the survivors showed increasing tolerance to this material. After the 15th to the 17th generation flies exposed to DDT and several other insecticides, including isobornyl thiocyanoacetate, chlordane, rotenone, chlorinated camphene, and pyrethrum, were more resistant to all of them than were those of the original strain. In general, there was little evidence that the flies developed specific resistance to DDT. However, the selected strain was less susceptible to all materials, so that about two or more times the concentration was necessary to obtain mortalities equal to those obtained with the original strain. When exposed to insecticide deposits, the special resistant strain was also more tolerant to DDT than were the regular flies. Residual tests were not conducted with other insecticides.

DDT applied as a fog aerosol failed to give satisfactory control of the *Hippelates* eye gnat in the Coachella Valley in California.

The relative effectiveness of chlordane and DDT was tested in the laboratory against a number of insects of military importance. As a space spray chlordane was slightly more effective than DDT against houseflies but only about one-third as toxic to yellow-fever mosquitoes. As a residual spray chlordane was less effective than DDT against both insects. Chlordane sprays were inferior to DDT sprays in field tests against adult salt-marsh mosquitoes.

As a larvicide for mosquitoes chlordane proved to be generally inferior to DDT when tested in the laboratory against *Anopheles quadrimaculatus* Say, *Culex quinquefasciatus* Say, *Aedes aegypti* (L.), *Aedes vexans* (Meig.), and *Aedes lateralis* (Meig.), and in the field against *Anopheles quadrimaculatus* at 0.1 and 0.05 pound per acre.

Indications are that good control of chiggers (*Eutrombicula* spp.) can be obtained with chlordane dusts at dosages of 2 to 4 pounds of chlordane per acre, although further tests are necessary before the effectiveness of the material can be fully established.

Chlordane proved superior to DDT against the lone star tick when applied as a dust at 2 pounds of active ingredient per acre.

Results of laboratory and field tests have confirmed reports that chlordane is an effective material for use against roaches. From the standpoint of initial kill it is far superior to DDT. In a limited number of tests with these insecticides applied as a spray and as fog aerosols, chlordane was more effective.

Chlorinated camphene proved inferior to DDT in laboratory tests against adult mosquitoes and houseflies, when employed as a space spray and also as a residual spray. It was also less effective against mosquito larvae, adult salt-marsh mosquitoes, and the American cockroach. This insecticide appeared promising against chiggers and ticks when employed as a ground treatment. In preliminary tests it proved equal to benzene hexachloride and pentamethylflavan against chigger mites and equal or superior to DDT against the lone star tick.

Tests with benzene hexachloride, both the gamma isomer and the technical product, indicate that the insecticide is not sufficiently effective against mosquito larvae to warrant its use in place of DDT. It is, however, more effective as a space spray against adult mosquitoes and houseflies. The gamma isomer proved to be about twice as toxic as DDT to yellow-fever mosquitoes and about six to eight times as toxic to houseflies.

Benzene hexachloride at 2 to 4 pounds of the crude insecticide per acre gave good immediate control of lone star ticks, but they revived and became active after several days.

Benzene hexachloride proved effective in destroying chigger mites when applied to their natural habitat. It was especially effective as a clothing treatment against chiggers. Clothing impregnated at the rate of 2 grams of gamma isomer per square foot protected the wearer against chiggers through 20 ordinary washings. The insecticide used in the same way is also highly effective against the lone star tick and fleas. Except for the disagreeable odor and possible toxicological hazards, benzene hexachloride would be an excellent clothing treatment for protection of the individual from attack by several important pests of man.

Of several pyrethrum synergists evaluated against houseflies, piperonyl butoxide proved to be the most effective.

Thirty insecticides and drugs, including DDT, pyrethrum, chlordane, rotenone, and chlorinated camphene, were tested to determine whether internal administration to a host (rabbit) would destroy bloodsucking insects that were permitted to engorge on it. Body lice and yellow-fever mosquitoes were employed as test insects. 2–Pivalyl-1,3-indandione proved highly active against the body louse. When administered as a single dose orally, subcutaneously, or intravenously, in doses as low as 2.5 mg. per kilogram of body weight, complete kill of lice was obtained when they were given a single blood meal. When incorporated in the food and given to a rabbit at 0.25 mg. per kilogram of body weight each day for 19 days, nearly complete kill of lice given a single blood meal was obtained after the first week. A 0.1-mg. dose did not kill many lice allowed one blood meal, but after repeated feeding on the host the lice did not survive longer than 3 days. Gamma-benzene hexachloride was the only chemical that proved highly active against mosquitoes when administered to the

host. A 25-mg. dose resulted in complete kill of engorged mosquitoes, and a 5-mg. dose in 93 percent kill. This material at 100 mg. per kilogram also killed natural infestations of ear mites in dosed rabbits. These tests were of a preliminary nature, and it is recognized that the two most active chemicals are toxic to warm-blooded animals. However, the findings show that bloodsucking insects can be killed by chemicals administered to the host at relatively low, nonfatal doses.

Laboratory tests indicated that DDT and gamma-benzene hexachloride at dosages as low as 1 part to 400 million parts of water will destroy larvae of the Clear Lake gnat. One part of pyrethrins to 2 billion parts of water was also completely effective. Chlordane was slightly inferior to DDT, and chlorinated camphene was much less effective. Field tests will be required to determine whether the use of larvicides will be economical and feasible for controlling this pest. If indicated to be practical, studies should be made to determine whether the treatment will destroy fish or otherwise upset the balance of nature in the lake.

By new technique for testing larvicides for the blackfly, developed at Corvallis, Oreg., laboratory, it was demonstrated that after 15 minutes of exposure about 60 percent of the larvae were killed at a dosage of about 1 part of DDT to 2 million parts of water.

Laboratory tests were initiated during the year to determine the toxicity of various insecticides to ants. Only two species, *Monomorium minimum* (Buckl.) and *Solenopsis geminata* (F.), have been employed thus far. DDT as a residual treatment was superior to pyrethrum, chlordane, and benzene hexachloride against these ants. Chlordane, which has been reported to be an excellent material for use against ants, proved to be relatively ineffective in these tests. Chlorinated camphene, although slower in action, was as effective as DDT several days after application.

RESULTS OF EXPERIMENTS AGAINST LIVESTOCK PESTS

Tests were continued to determine the best concentration of DDT to apply to cattle for horn fly control. In Florida tests on several thousand cattle indicate that a 1.5-percent DDT spray applied at the rate of about 1 to 1½ pints per grown animal will give protection for about 5 weeks. Sprays containing 0.5 and 1 percent of DDT applied at the same rate protected animals for about 3 and 4 weeks, respectively. In the Middle West DDT sprays applied to a few herds of cattle at concentrations ranging from 0.25 to 1.5 percent, using 2 quarts of spray per animal, showed no clear-cut relationship between concentrations and duration of effectiveness.

Tests indicate that DDT offers little promise for the protection of cattle from attacks by the horse fly.

The place of DDT in control of ticks on livestock has been given further consideration. An important development in this field is the promise shown for the control of the Gulf Coast tick. Tests in Florida indicate that 2.3-percent DDT sprays applied to the entire animal will give good protection for a month. Results were comparable with those obtained by treating the ears with DDT in a nondrying adhesive. If further tests bear out these preliminary observations, DDT sprays will have a number of advantages, since they are more practical than ear treatments and at the same time provide excellent control of horn flies and lice.

Good control of unengorged stages of the lone star tick was obtained with DDT sprays at a concentration of 0.75 percent, but only about 50 percent of engorged ticks were killed with 1.5 percent of DDT in 48 hours. DDT did, however, provide fair protection from reinfestation.

Dusts containing 2 percent of DDT gave good control of the winter tick, although results were not equal to those obtained with chlordane and chlorinated camphene.

In the Southeast routine applications to cattle of a 1.5-percent DDT spray during the horn fly season gave excellent control of lice. A single thorough treatment appeared to provide good control of *Haematopinus quadripertusus* Fahrenholz. This species is indicated to be more resistant to DDT than is the related species *H. eurysternus* (Nitz).

In laboratory tests against early stages of deer fly larvae found in Oregon, DDT was shown to be toxic at concentrations of about 2 parts per million as long as the larvae were in water; it was not effective against larvae embedded in mud. DDT applied with a fog generator did not provide satisfactory control of adult deer flies.

Benzene hexachloride proved to be more toxic than DDT to sucking lice on cattle and biting lice on goats. When applied on small patches of an infested animal, benzene hexachloride dust containing 0.1 percent of the gamma isomer gave complete control of lice within the treated area and a marked reduction for some distance outside. This result suggests fumigating action. The treated area was free of lice for 12 days as compared with 6 days when DDT was used.

Benzene hexachloride killed all motile forms of red and yellow biting goat lice at a concentration of 0.01 percent of the crude material, whereas incomplete kill was obtained at the same concentration of DDT.

When applied to infested animals, benzene hexachloride proved far more toxic than DDT to lone-star ticks, both unengorged and engorged. Benzene hexachloride does not, however, have a lasting effect on this tick and treated animals become heavily reinfested within 2 weeks.

Benzene hexachloride proved ineffective at concentrations as high as 1 percent of the gamma isomer, when tested in Oregon against larvae of the common cattle grub. It was also relatively ineffective for horn-fly control because of its short residual action.

Chlordane and chlorinated camphene were evaluated in a preliminary way against several pests of livestock. Against the lone-star tick they proved more effective than DDT in producing initial kill of both engorged and unengorged ticks, but they were inferior to benzene hexachloride. From a residual standpoint, however, these two materials were superior to benzene hexachloride and possibly equal to DDT. They also proved superior to DDT against the winter tick in both initial kill and prevention of reinfestation.

Tests with 1-percent dusts indicated that both chlordane and chlorinated camphene were promising treatments for lice on cattle. Chlordane at this concentration did not seem so effective from a residual standpoint as did DDT, but chlorinated camphene was equally effective. Both materials killed the motile forms of red and yellow goat lice at concentrations as low as 0.05 percent. The two materials appeared equal to DDT when tested at 0.01 percent, but complete kill was not obtained.

Neither chlordane nor chlorinated camphene was effective against horseflies on cattle. A combination of pyrethrum and piperonyl cyclonene offered some promise for the control of horseflies on cattle.

Because of the shortage of turkey-red oil used in smear 62, the screwworm remedy developed in the Bureau several years ago, efforts have been concentrated on other suitable preparations, which use more readily available materials. A formula known as EQ smear 82, in which *n*-butyl alcohol and a sodium salt of an alkylated aryl polyether sulfate are substituted for turkey-red oil, was recommended during the year as an alternate treatment.

IMPROVEMENTS IN METHODS AND EQUIPMENT FOR APPLYING INSECTICIDES

LIQUEFIED-GAS AND HEAT-GENERATED AEROSOLS

Further investigations on the chemical phases of aerosols have disclosed that carbon dioxide absorbed in acetone can be used as an inexpensive solvent and propellant for aerosols for field use. With this propellant, aerosol formulations of derris resin, DDT, pyrethrum, the dimethoxy analog of DDT, and gamma-benzene hexachloride were prepared for field tests during the 1947 season. As mentioned elsewhere in this report, aerosols of hexaethyl tetraphosphate in methyl chloride have given good control of a number of species of aphids and some other insects in greenhouses. Similar formulations are being tested in the field. Propellants for low-pressure aerosols have also been studied. Development of aerosols with a gage pressure in the container of less than 25 pounds per square inch will permit the use of inexpensive "beer can" containers. A nozzle has been designed for use with low-pressure formulations, which produces a dispersion as effective against houseflies as the high-pressure aerosols now in use.

The use of liquefied-gas aerosols to destroy agricultural pests and insect vectors of disease in airplanes is under investigation with regard to the development of effective formulations and efficient methods of application. During the year aerosol formulations and dosages were developed and recommended for the elimination of Japanese beetles in airplanes leaving the regulated area. DDT residues in airplanes were found to be toxic to beetles for at least 86 days after application. The persistence of such residues on different surfaces and their effect on these surfaces were studied.

Tests were made in the use of heat-generated aerosols against a wide range of agricultural pests. Effective control with economical dosages was obtained on a number of pests that were in flight at the time of treatment, notably horn flies on cattle, and plant bugs, *Lygus* bugs, and leafhoppers on field and vegetable crops. The dosage required for the treatment of insects not in flight equaled or exceeded that used when the insecticides were applied in dust or spray form.

Studies on the performance of the aerosol cloud revealed that the optimum wind velocity is one-half mile per hour, and that satisfactory results can be obtained at velocities up to 8 miles per hour. Under favorable atmospheric conditions at night, the aerosol is effective up to 1,500 feet from the generator.

An exhaust generator for 1½-horsepower gasoline motors was developed which produces an aerosol of 11 microns average particle size and has a capacity of 3½ liters per hour. This generator is

easily carried by hand and is useful in the treatment of enclosed places, such as barns, greenhouses, and warehouses.

FOG GENERATORS TESTED AGAINST FRUIT INSECTS

In California a concentrated (25-percent) solution of DDT in oil, dispensed as an aerosol by a fog generator, gave an excellent kill of grape leafhoppers, principally *Erythroneura elegantula* Osb., for a distance of 250 to 300 feet downwind, a lesser kill for 300 to 500 feet, and little or no kill beyond 500 feet. Minor injury on the growing tips of the vines and on berries on the windward side of the rows was evident for 75 to 100 feet into the vineyard. In Ohio fog applications of DDT gave poorer control of the grape berry moth than did regular spray applications and at a higher cost for materials. The fog was ineffective beyond a distance of 15 feet.

At Yakima, Wash., several fog applications of concentrated nicotine and DDT were made for the control of aphids on apple and prune trees. At about 55° F. an aqueous nicotine solution killed only about half the green, rosy, and woolly apple aphids on apple. At the same temperature an aqueous-oil emulsion of nicotine killed about half the aphids on prune trees, whereas a DDT-oil solution killed practically none. At higher temperatures a solution of nicotine killed 80 to 90 percent of the aphids in the well-fogged part of prune trees. At Poughkeepsie, N. Y., nicotine fogs were about as effective as mist sprays in killing pear psylla adults. Fogs generated from concentrated kerosene solutions of nicotine were more effective than those from water solutions.

MIST BLOWER MAY HAVE WIDE USE

Experiments with mist blowers for the control of insects affecting forest and shade trees were continued in cooperation with the Connecticut Agricultural Experiment Station and manufacturers. A very effective 25-horsepower outfit, mounted on a truck, will treat 100 to 200 acres of forest plantations per day at the cost of approximately $1 per acre. A large shade tree can be treated with 1 pint of concentrated spray, the equivalent of 30 to 40 gallons of dilute spray applied by a power sprayer. Further improvements were made in a wheelbarrow type of mist blower, and machines of this type are now being placed on the market by several companies.

In preliminary experiments the application of DDT with a mist blower to prevent feeding by bark beetles on elm twigs gave promising results.

Against fruit insects tests of mist blowers were confined to work on the codling moth and the pear psylla. For general orchard use the mist-blower type of equipment appears to have greater possibilities than the fog generator. Tests against the codling moth were principally with DDT solutions and emulsions, and the results are given elsewhere in this report. Against the pear psylla a kerosene solution of nicotine continued to be superior to other formulations, although water solutions showed promise when a wetting agent was included. High percentages of nymphs, as well as adults, were killed. Two concentrated mist sprays, one containing pyrethrum and a commercial synergist having a methylene dioxyphenyl grouping and the other containing hexaethyl tetraphosphate, were ineffective.

FURTHER PROGRESS IN APPLICATION OF INSECTICIDES FROM THE AIR

The past year has witnessed a greatly expanded interest in aerial application of insecticides for the control of forest insects, not only in those governmental agencies responsible for the protection of timber stands, but among private organizations as well. Complete protection for the thousands of acres of timberlands defoliated each year, heretofore hopelessly, now seems possible at a cost of $1 per acre. There is much still to be done in both research and practical application, and every effort is being made within the facilities of the Bureau to hasten progress in this field.

In studies of aerial spraying apparatus and flight procedures at Beltsville, Md., it was found that hollow-cone nozzles having ⅛-inch orifices produced a more nearly uniform deposit than did jets, sleeves, and flat atomizing devices. It was also found that, with light aircraft in calm air, (1) releasing the spray at altitudes from 50 to 200 feet did not increase the lateral distribution (swath width) of the deposit, and (2) increasing the output of spray (flow rate) from 1 gallon to 2 gallons per acre, by doubling the number of nozzles, did not materially change the swath width or the droplet spectrum of the deposited spray. These points have been the subject of some speculation among persons working with aerial sprays and are of considerable practical importance. Some preliminary tests have been made in an effort to utilize crosswind drift for obtaining wider and more uniform distribution of spray.

Airplane applications of DDT at dosages of 1 and 2 pounds in 1 gallon of liquid per acre gave good control of the Saratoga spittle bug on jack pine and red pine in Wisconsin and Michigan, when the spray was applied just after the adults appeared on the trees. Good control of the red-headed pine sawfly in Wisconsin, Michigan, and New York was obtained with 1 pound of DDT in 1 gallon of spray per acre. It is believed that even lower dosages will be effective when further improvements are made in spray formulas, equipment, and operating technique.

Aerial spray applications for control of the European corn borer, using fixed-wing planes with boom attachment, indicate that maximum performance might be expected under the following conditions: (1) with 46 or more nozzles distributed largely toward the distal ends of the boom; (2) with nozzles having $\frac{1}{16}$-inch orifices; (3) with hydraulic pressure of 50 pounds or more; (4) at 70° F. air temperatures or higher; (5) with crosswinds of less than 3 miles per hour and less than 10° deflection; (6) when the flight height is 2 to 3 feet above plants; (7) at ground speed of 55 miles per hour. Oil sprays provided somewhat better plant protection than emulsions and gave wider swath widths.

New equipment utilizing a jettison tank on a PT-17 (Stearman) plane was developed for use in mosquito control work. This equipment has the advantage of being readily removed and replaced with various types of tanks, and in an emergency it can be jettisoned while the plane is in flight. Equipment utilizing this type of tank has been constructed for applying solutions, suspensions, and dusts. The equipment for applying the suspensions consists of nozzles on a spray boom beneath the wings. A centrifugal pump with a wind-driven propeller is utilized to force the spray out of the nozzles. A portion

of the solution is forced back into the tank to provide agitation to keep the insecticide in suspension. Solutions can also be applied with this equipment if high pressure and small spray droplets are not necessary, but a gear pump substituted for the centrifugal pump is more desirable. Experimental dust equipment utilizing the same type of tank has been constructed.

The results of large-scale experiments with new insecticide dusts applied by airplane for the control of insect pests on cotton are discussed elsewhere in this report, as are also large-scale programs involving the distribution of insecticides from the air.

FUMIGATION

An appraisal of the blower applicator for applying hydrocyanic acid gas in citrus fumigation indicated a need for further development before it can be put into practical use. Improvements designed to increase operating speed include installation of a larger wheel, replacement of the multivane blower by a propeller fan, and the use of a larger pump and larger nozzles. Tests of the improved blower are now under way in cooperation with commercial fumigators. Field tests have been continued with different kinds of fabrics for use in fumigation tests. Poplin, glass cloth, and one sample of nylon coated with a polyvinyl chloride plastic proved unsatisfactory for gastight tents. Sateen coated with the same plastic was superior to Army duck, but lost much of its gastightness after being in field use for only about 5 months. Drill coated with a polyvinyl butyral plastic deteriorated rapidly. A 28-inch propeller-type fan in the gas evacuator developed to remove residual gas from gastight tents at the end of the exposure exhausted sufficient gas in 50 seconds to insure the safety of the tent-pulling crews.

Methyl bromide fumigation schedules were developed and approved for sacked cottonseed in approved fumigation chambers as an alternative to a second heat treatment for the movement of seed from areas regulated by pink bollworm quarantines. Tests conducted in cooperation with the southern regional laboratory of the Bureau of Agricultural and Industrial Chemistry showed no deleterious residue in cottonseed oil or cake from fumigated cottonseed.

A laboratory was established during the year at Lafayette, La., for the study of problems bearing on the commercial fumigation of sweetpotatoes for sweetpotato weevil. Present fumigation practices with methyl bromide often injure the potatoes, and the studies will be directed toward determining the causes of such injury and the development of methods whereby it may be eliminated.

Emphasis on fumigation treatments for elimination of white-fringed beetle larvae in nurseries has been centered largely in Georgia as a result of the finding of heavy infestations in that State. Schedules for treatment under Georgia conditions have been developed, and large numbers of nursery plants have been fumigated successfully.

DIPS AND SOIL TREATMENTS

Further work in New Jersey with ethylene dibromide resulted in its use as a dip for the treatment of bare-root nursery stock to destroy Japanese beetle grubs for quarantine certification. In tests with different soil mixtures the effectiveness of this fumigant in killing Jap-

anese beetle grubs in the soil decreased, in general, as the amount of peat in the soil mixture increased. A combination DDT-ethylene dibromide soil treatment was found to be highly satisfactory when both immediate kill of grubs and lasting effectiveness were desired. Concentrations of ethylene dibromide needed in dips and soil treatments for European chafer grubs were higher than needed for the Japanese beetle and on the borderline of those safe to use.

An extended series of experiments has been set up to determine the practicability of DDT soil treatments as a basis for certification of nursery plants under the white-fringed beetle quarantine regulations. Seventy-three nursery plots, treated with various dosages of DDT, will be observed over a 2-year period.

NATURAL ENEMIES OF VARIOUS PESTS INVESTIGATED

BENEFICIAL INSECTS BOTH IMPORTED AND EXPORTED

Large-scale collections of vegetable weevil larvae for parasite rearing were made in Uruguay and Argentina. The parasite population was low during the 1946 season, and only one small consignment of *Porizon* spp. became available for shipment to California. One small consignment of *Paratheresia diatraeae* Brethes was assembled in Uruguay and forwarded to the Puerto Rico Agricultural Experiment Station.

Shipments of leaf-feeding insects from Australia for the biological control of the Klamath weed consisted of 101,000 adults of *Chrysolina hyperici* Foerst. and *C. gemellata* Rossi. Field establishment in California has already been demonstrated in all the colonies of both species released during the last two years.

In cooperation with other Bureau as well as State agencies, arrangements were made for forwarding consignments of *Allotropa burrelli* Mues., *A. convexifrons* Mues., and *Pseudophycus malinus* Gahan, parasites of the Comstock mealybug, to Canada, of *Macrocentrus ancylivorus* Roh. to Argentina and Italy for control of the oriental fruit moth, and of *Copidosoma koehleri* to Italy for use against the potato tuberworm.

PARASITES SAVE NEARLY 2 MILLION POUNDS OF SUGAR

An estimated saving of 1,900,000 pounds of the 1946 sugar crop, with a value of $75,000, resulted from reductions of sugarcane borer populations in Florida brought about by beneficial parasites that had previously been introduced into the area.

EUROPEAN CORN BORER PARASITES RELEASED IN 14 STATES

In cooperation with State agencies over 400,000 parasites of the European corn borer, involving five exotic species, were released in the United States in 1946. Except for one species, *Eulophus viridulus* Thoms. which was provided from laboratory-reared material through cooperation with the Canadian Science Service, the parasites were obtained from collections in Connecticut, Massachusetts, and New Jersey. Colonies were released in Delaware, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Minnesota, New York, North Carolina, Ohio, Pennsylvania, Virginia, and Wisconsin.

PARASITES ACTIVE AGAINST THE SPRUCE BUDWORM

The spruce budworm in the Adirondack area was found to be rather heavily parasitized. Certain samples showed as high as 44 percent parasitization of the hibernating larvae, 46 percent of the large larvae, and 59 percent of the pupae. Large-scale collecting of budworm material and rearing of parasites were conducted in Colorado. A total of 11,150 specimens of *Ceromasia auricaudata* Towns, a species that does not occur in the East, were sent to the Adirondacks and released. There are at least two other species of budworm parasites in Colorado that are not native in the East, but they do not yet occur in sufficient numbers for mass collections to be made.

REARING OF MACROCENTRUS ANCYLIVORUS FURTHER DEVELOPED

Although the breeding rate of the oriental fruit moth parasite *Macrocentrus ancylivorus* Roh. fell below expectations in 1946 at the Moorestown, N. J., laboratory owing to adverse weather conditions, high production was attained, and shipments for liberation were made to State agencies in New Jersey, Georgia, Louisiana, Kentucky, Ohio, Indiana, Idaho, and Oregon.

When bred in the laboratory on the potato tuberworm, this parasite is subject to attack by a *Nosema* disease. A highly practical method has been developed for controlling this disease in rearing stocks, which involves subjecting the eggs of the host species to a temperature of 47° C. for 20 minutes before they are incubated. Persistent use of this process has completely eliminated the disease, which formerly affected about 50 percent of the parasites. Experimental liberations of six female parasites per tree reduced oriental fruit moth injury by 82 percent in peach orchards in southern New Jersey, and a combination of bait traps to capture adult moths and releases of three female parasites per tree did nearly as well.

ARTIFICIAL CULTURE MEDIUM SOUGHT FOR MILKY DISEASE OF JAPANESE BEETLE

Bacillus popilliae Dutky, the causal agent of type-A milky disease of the Japanese beetle, has now been under continuous cultivation on artificial media for almost a year, but only the vegetative form has thus far been produced. Cultures carried through numerous transfers produced typical disease symptoms and abundant spores when injected into Japanese beetle larvae. Factors affecting culture yields were carbohydrate content, pH, buffer capacity, and thiamin content of the medium. *B. lentimorbus*, the causal agent of type-B milky disease, was also cultured with somewhat similar results. An apparently new milky disease organism, somewhat similar to but smaller than *B. lentimorbus*, was found in material from Maryland.

The cooperative milky disease distribution program resulted in the treatment of approximately 9,500 acres with milky disease spore dust during 1946 in 11 States from Massachusetts to North Carolina and west to Ohio.

POLYHEDRAL DISEASE AND PARASITES CONTROL HEMLOCK LOOPER

Studies of a hemlock looper outbreak, which began in 1944 in Oregon and Washington, were continued in 1946. In Pacific County, Wash., it was found that a polyhedral disease which was noted late

in 1945 continued to develop and by the end of 1946 had reduced the looper population to a very low level. In Clatsop County, Oreg., this virus disease was not so evident, and it appeared that parasites, of which 14 species were noted, probably played a more important role. The population in this area was greatly reduced by aerial spraying in 1945 and did not build up to destructive proportions again in 1946.

EFFECT OF INSECTICIDES ON PARASITES AND PREDATORS BEING STUDIED

A laboratory was established at Yakima, Wash., early in the year to study the effect of applications of DDT for codling moth control on the natural enemies of this pest and associated pests of apple, such as the Pacific mite and the woolly apple aphid. The last two pests increase greatly in orchards treated with DDT for codling moth control. The increased woolly aphid infestations are followed by outbreaks of perennial apple canker. The causes for the increase of these pests must be determined so that modifications may be made in the spray program to eliminate this effect.

STUDIES CONTINUED ON PLANTS RESISTANT TO INSECT ATTACK

Investigations in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and interested State agencies, were continued on the resistance of wheat and barley to the hessian fly, of sugarcane to the sugarcane borer, of corn to the European corn borer and the corn earworm, and of alfalfa to the pea aphid. Further progress was made toward the production of commercially desirable varieties resistant to these insects, although only one new release, the dent corn inbred P8 resistant to the European corn borer, was made during the year. Five sister lines of a resistant soft red winter wheat, which derives its resistance from Illinois No. 1–W38 and is being considered for early release by Indiana, maintained their high resistance on exposure in the field to spring and fall broods of the hessian fly. The agronomic characteristics of two of these lines are outstanding. In addition to their fly resistance, these lines are also resistant to leaf rust, loose smut, and mosaic. In Kansas a hybrid wheat resistant to the fly, rust, and loose smut, deriving its fly resistance from Kawale-Marquillo, is one of the most promising new varieties under observation.

Resistance of dent corn to earworm attack is apparently of two kinds, resistance to establishment of the larvae and resistance to damage by larvae that do become established. Observations in Mississippi showed that long, tight husk extension will not protect corn from damage by the earworm, but that a 2- or 3-inch husk extension is essential to protect the ears from attack by the rice weevil and other insects, as well as by birds and diseases.

Studies on the development of strains of cotton resistant to the cotton aphid were continued at the Stoneville, Miss., laboratory in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the State Agricultural Experiment Station. Classification of 3,180 plants of the F_2 generation from 11 crosses of glabrous X hairy parents showed that 4 of the progenies segregated into a ratio of 1 pilose: 2 intermediate: 1 glabrous, indicating that they may have been obtained from segregation of a single pair of factors. The data suggested that the differences between the glabrous and hairy parents in these crosses were due to a small number of factor pairs. However,

the number of factor pairs involved might vary with different parental crosses, because the ratio was different in the other 7 crosses. It was also found that aphid resistance was definitely correlated with glabrousness in the F_2 generation.

More than 200 glabrous cotton plants were selected in 1946, and the seed was planted in 1947 for observation. Seed from over 250 intermediate plants were planted in order to study further segregation. Between 7000 and 8000 plants are available for aphid-resistance and inheritance studies during the crop season for 1947.

One of the smooth-leaf, aphid-resistant strains of cotton produced outstanding grades in mechanization studies in 1945 and 1946. On the basis of this performance and the need for grade improvement in machine-picked cotton, the Delta Branch of the Agricultural Experiment Station, in cooperation with this Bureau and the Bureau of Plant Industry, Soils, and Agricultural Engineering, has given the name "Delta Smooth Leaf" to this strain, and designated it as an experimental variety. Pure-line seed has been supplied the Delta Branch station for distribution to plant breeders. A highly significant correlation between pilosity and grade was found to exist with as much as two grades difference between the Delta Smooth Leaf strain and other leading pilose varieties in machine-picked cotton. Wide differences also occurred in hand-picked samples. Because of the serious decline in the better grades of American cotton in the last 20 years, it is apparent that the discovery of the connection between glabrousness, aphid resistance, and better grades can be of great economic importance to southern agriculture.

Cooperative studies at the Institute of Forest Genetics at Placerville, Calif., showed that certain strains of hybrid pines are more resistant to attack by the pine reproduction weevil (*Cylindrocopturus eatoni* (*Buch.*)) than are the parent strains. This opens up a wide field of investigation to determine the reason for such resistance and whether the trees will also prove resistant to other species of insects. Some of the hybrid strains are very susceptible, indicating that insects must be considered along with other factors in this tree-breeding work.

INSECTS IN RELATION TO SPREAD OF PLANT DISEASES

In southern California only 5 new cases of peach mosaic developed during 1946 in a 1,023-tree block of peach trees sprayed that season in a replicated plot arrangement with nicotine sulfate, DDT, and benzene hexachloride. Lime-sulfur and basic lead arsenate were applied to all plots. There were 28 new cases in this block in 1945, and more had been expected in 1946. It is assumed that the spraying reduced the incidence of the insect vector responsible for spreading the disease, even though its identity has not been established.

Certain leafhoppers are now under suspect as vectors of the virus responsible for western X disease and cherry wilt, since in field plots maintained by cooperating agencies near Salt Lake City, Utah, two trees exposed to their feeding in 1945 showed symptoms of the disease in 1946. One case of natural spread occurred in the same plots.

Mosaic disease of carnation was found to be transmitted by the green peach aphid (*Myzus persicae* (Sulz.)). Evidence was obtained that the aphid *M. dianthi* (Shrank), previously thought to be synonymous with *M. persicae*, is a distinct species. Direct injury to carna-

tion by the two aphids differs, injury by *M. dianthi* being similar to streak disease. Progress was made in distinguishing the vector relationships and host differentiation of several viruses of plants of the iris family.

RESEARCH ON HONEYBEES AND WILD POLLINATING INSECTS

POLLINATING INSECTS RECEIVE INCREASED ATTENTION

Modern agricultural practices have made such inroads on native pollinating insects that corrective steps must be taken if high production is to be maintained in the large number of important insect-pollinated crops. The continuous and serious decline in the yield of legume seeds, in particular, is due in part to a deficiency of pollinating insects. Work on this problem was initiated during the year, with headquarters at Logan, Utah, where investigations are being made on insects effective in the pollination of western legumes, particularly alfalfa, and at Columbus, Ohio, where emphasis is being placed on the insect pollination of red clover in the Eastern States. The investigations will cover not only the value and the efficient utilization of the honeybee for this purpose, but also the biology, diseases, and methods of propagation of wild pollinating insects, especially the bumblebee and other wild bees.

In a study of wild-bee pollinators of alfalfa made in California, nests of two or three species of *Megachile*, which are among the most efficient pollinators of this crop, were found in the stalks of elderberry, star-thistle, wild tobacco, milkthistle, and a few other hollow-stemmed plants. A nest was found in a cottonwood log. Nests of *M. brevis* (Say) (tentative determination) were most abundant in milkthistle. This species utilizes stems that have been cut or broken off in a way to expose the hollow cavity.

The number of honeybee visitors to neighboring alfalfa plots in northern Utah was in direct proportion to the amount of bloom. Profuse blossoming alone, however, does not guarantee a good crop of seed. In southern Idaho few bees were observed in the fields although there was a wealth of blossoms, for honeybees had been moved out of the locality the previous year.

Of the season's collection of pollen in a single hive in Arizona, approximately 10 pounds was alfalfa. To obtain this quantity it has been estimated that over 3.6 billion alfalfa blossoms were tripped by this one colony.

ARTIFICIALLY INSEMINATED QUEEN BEES HIGHLY RESISTANT TO DISEASE

For the first time only artificially inseminated queens were used in the studies on resistance to American foulbrood. Forty-six queens of two lines showed 91 percent and 13 queens of a third line gave 100 percent resistance. The queens used for one of the first two lines were mated with their brothers, whereas those of the other lines were mated with drones from other colonies of the line to which they belonged. A few queens representing a triple cross of these three lines were 100 percent resistant. In all cases resistance was higher than for the same lines last year. Less susceptibility to European foulbrood was also observed in 1946 than in the preceding year.

Of 590 queens artificially inseminated for the disease-resistance and stock-improvement studies, 62 percent started laying and 316 of these

queens were sent to the laboratories in Wyoming and Wisconsin, where these studies are being made.

SULFATHIAZOLE RETARDS AMERICAN FOULBROOD

Culture studies continued to indicate that, when sulfathiazole is fed to colonies in sugar sirup or pollen cakes, it may retard the germination of American foulbrood spores ingested by the bee larvae until the latter have passed the susceptible stage. A concentration of 75 mg. per 100 grams seemed to be the approximate border line above which definite inhibition of spore germination was found. Although concentrations as high as 300 mg. per 100 grams had a definite inhibitory effect, they were not completely bactericidal.

When individual larvae were inoculated, American foulbrood spores subjected to a concentration of 15 mg. of sulfathiazole per 100 grams for 48 hours appeared to be still capable of producing disease.

Feeding sulfathiazole in a concentration of 0.5 gram per gallon of sugar sirup to colonies infected with American foulbrood appeared to check the spread of infection in most of the colonies. It had no effect on the Nosema disease, European foulbrood, or sacbrood, or any significant effect on the temper or vigor of bees.

NOSEMA INHIBITED BY AN ARSENIC COMPOUND

Of several chemicals tested for controlling Nosema disease, carbarsone, a compound containing arsenic, showed the greatest inhibitory effect when tested on bees in cages. A concentration as low as 0.25 percent was found to arrest the disease, but it shortened the life of the bees. A concentration of 0.05 percent in sugar sirup fed to four infected colonies failed to show any inhibitory effect.

AMERICAN FOULBROOD SPORES PRODUCE FOUR ANTIBIOTICS

An outstanding feature of the year's work was the demonstration that *Bacillus larvae*, the organism causing American foulbrood in honeybees, produces, not one, but four separate antibiotic substances, one of which is active against the bacillus responsible for an important disease of man.

By appropriate chemical treatment the toxicity of these antibiotics has been greatly reduced, sometimes to the point where none could be detected. However, optimum conditions for obtaining them must be worked out, especially since slight changes in technique or reagents frequently greatly modify the product obtained, with respect to both potency and toxicity. Relatively nontoxic solutions that are very active against the tubercle bacillus have been obtained repeatedly.

OBSERVATIONS ON DDT IN RELATION TO HONEYBEES

Commercial applications of DDT to alfalfa-seed fields in Utah for the control of *Lygus* bugs killed some of the field bees. Brood was not affected. The damage resulted from dusts applied when the fields were in flower, which is contrary to recommended practices. The application of DDT, however, increased the flowering of alfalfa about eightfold over undusted plots. The honey crop was larger than in preceding years in spite of bee losses. Some injury was also obtained in alfalfa

fields in California, and the bees stored little honey. DDT was recovered through chemical analysis of samples of dead bees.

Extensive DDT applications for the control of citrus thrips in central California, on the other hand, caused little or no trouble to beekeepers. They harvested a good crop of honey.

Surfaces sprayed with suspensions of DDT in water were generally toxic to honeybees brought in contact with them. The toxicity varied with the dosage and the exposure period. When 0.5-gram dosages of 1-percent suspensions were applied to small cages, the residue killed most of the bees in contact with it for 15 minutes or longer, but concentrations of 0.1 percent had little effect.

Dusts containing 5 percent of DDT were highly toxic to caged bees whether applied directly to the bees or to the cages alone, dusts containing 2 percent of DDT caused some mortality, while dusts of 1 percent or less were relatively harmless. When caged bees came in direct contact with DDT dust, they were repelled and discarded adhering dust. There was no indication that the bees could detect DDT on sprayed surfaces, however, or that the odor was repellent.

Queen-cage candy containing 0.5 percent of DDT and pollen paste containing 5 percent of DDT killed all bees feeding upon them, but pollen paste containing 0.5 percent killed but few. The bees eagerly consumed the queen-cage candy, whereas those offered pollen paste consumed little of it.

2,4-D NOT TOXIC TO BEES

In limited laboratory tests bees fed various concentrations of 2,4-D in sugar sirup lived as long as bees not so fed and behaved normally. Dandelions sprayed with 2,4-D showed no blossoms after 24 hours, and therefore would not be attractive to pollinating insects.

BEES PREFER POLLEN SUPPLEMENT TO SUBSTITUTES

Colonies given a choice between pollen supplement and substitutes showed marked preferences in the following order: Pollen plus soybean flour, soybean flour alone, soybean flour plus brewers' yeast, and soybean flour plus brewers' yeast and dried egg yolk. There was no marked difference in the amount of brood produced by colonies fed the different pollen substitutes.

SURVEYS DISCLOSE SPREAD AND OUTBREAKS OF INJURIOUS INSECTS

INSECT PEST SURVEY FILES PROVIDE NEEDED INFORMATION

Approximately 4,000 reports on insect conditions were transmitted to the Insect Pest Survey during the year from Bureau, State, and other collaborators. The information contained in these reports was abstracted, summarized, and incorporated into 7 monthly and 1 annual summary of insect conditions throughout the United States. These summaries were made available to entomological workers, insecticide manufacturers and distributors, and others needing current information on the distribution, occurrence, and abundance of the more important insect pests. The records received on each insect were incorporated into the permanent files maintained by the Insect Pest Survey, bringing to nearly 350,000 the number of individual records on domestic insects now available for ready reference. These records cover

about 8,000 genera and 23,000 species of insects recorded from this country. The data in these files were used during the year to provide detailed information, including the preparation of several distribution maps, in response to about 60 requests from entomologists and others. Eight special supplements to the Insect Pest Survey Bulletin were also published during the year.

TWO SERIOUS CORN PESTS NEARLY MEET

Of particular concern in the production of the Nation's corn crop was the continuing spread of the southwestern corn borer in a northeasterly direction and of the European corn borer in a southwesterly direction. As will be observed in figure 1, these two extremely

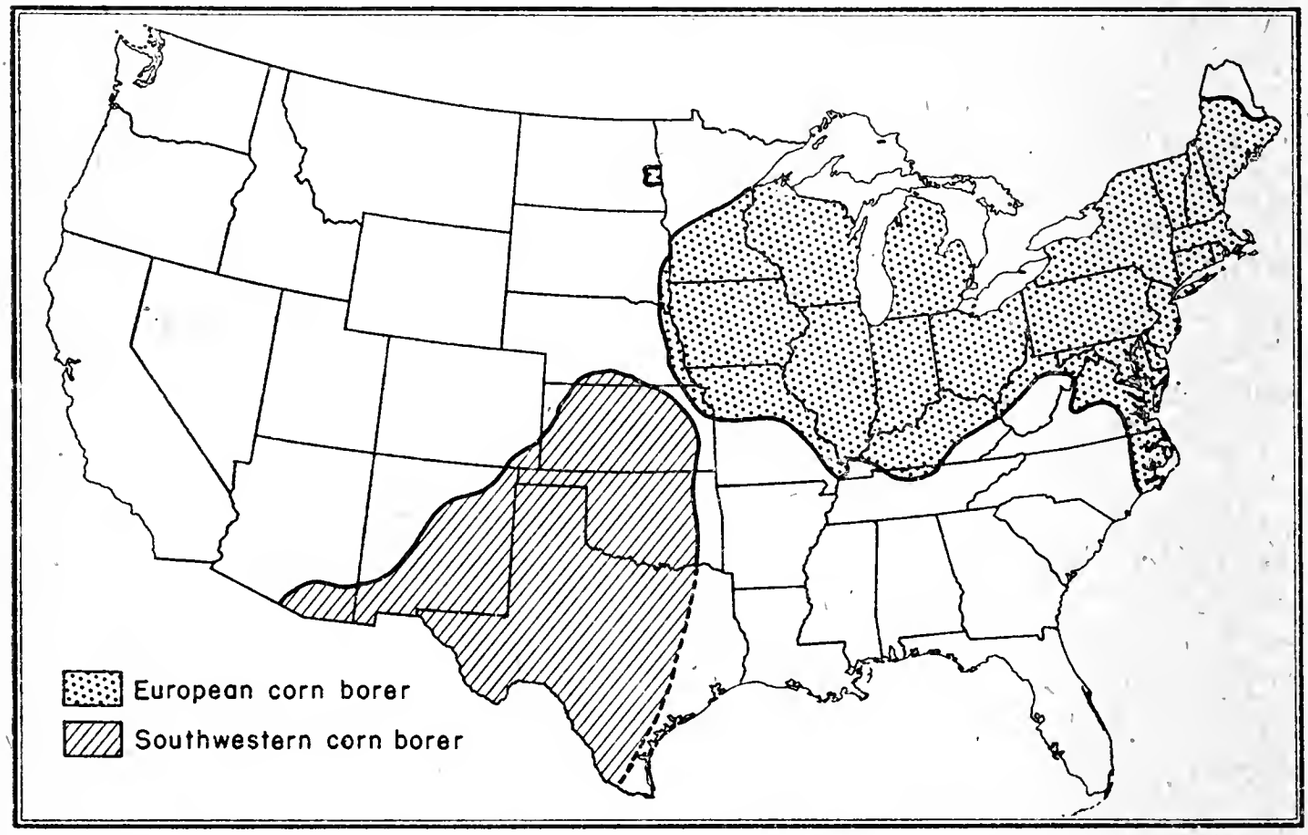

FIGURE 1.—Approximate distribution of the European and southwestern corn borers in the United States in 1946. (Eastern limit of infestation in Texas unknown.)

important pests of corn have almost met in northeastern Kansas. The occurrence of both these pests in the same area will materially aggravate the problem of control, as some of the main cultural practices now depended on for their control, such as planting dates and treatment of crop remnants in infested fields, are exactly opposite for the individual species.

The European corn borer increased in abundance in Iowa, Minnesota, and North Carolina and decreased in all other States included in the abundance survey. Two States, North Dakota and South Dakota, and 45 counties in previously infested States were added to the known infested area. It is estimated that this borer caused a total loss of about $37,000,000 in 1946, about $35,000,000 of which was in dent corn and $2,000,000 in sweet corn.

SURVEYS HELP REDUCE LOSSES FROM VELVETBEAN CATERPILLAR

The 1946 outbreak of the velvetbean caterpillar was one of the most widespread and intense on record, characterized by an early initial

appearance of the caterpillar in the southern extremes of the affected area, rapid build-up of populations to destructive abundance, and eventual extension of its occurrence into southern Virginia. Despite these developments, losses were much lower than have been experienced in previous outbreaks, principally as a result of prompt attention to control measures and the general adequacy of insecticide supplies to meet local demands, following timely reports by cooperating State and Federal agencies on the occurrence and abundance of the insect throughout the season. Such losses as did occur were due largely to growers' delays in applying control measures and to temporary shortages of insecticides occasioned by heavy demands as the infestation developed.

Estimates of crop losses and savings were made by entomologists in the areas most seriously affected. In Georgia, where the supply of cryolite was short throughout the season, an estimated loss of 5 percent was caused to an $80,000,000 peanut crop, and an estimated saving of almost $10,000,000 resulted from control operations. In Alabama losses to peanuts and soybeans were estimated as $500,000 and savings as $5,000,000. In South Carolina losses of soybeans were estimated at $100,000, and savings to this crop at $50,000. With greater recognition by growers of the need for applying control measures promptly and of the effectiveness of these measures in reducing or preventing losses, more extensive and effective application of control measures may be anticipated in future outbreaks of this pest.

COMSTOCK MEALYBUG POPULATIONS AT LOW LEVEL

In Virginia populations of the Comstock mealybug in 1946 averaged less than one-third those of 1945, and with few exceptions a similar condition prevailed in West Virginia, Ohio, Delaware, New Jersey, and Connecticut. This reduction was more pronounced in DDT-sprayed orchards than in those sprayed with lead arsenate, despite the fact that not a single parasite was reared from any orchard block where a regular DDT spray program was used for codling moth control. Parasitization of the mealybug was lower than usual, even when no DDT was used, because of the scarcity of the host.

MANGO FRUITFLY DISCOVERED IN HAWAII

The mango fruitfly (*Dacus dorsalis* Hendel) was found in Hawaii in May 1946. It has spread widely through the islands, more than 30 kinds of fruits, including mature green banana, having been recorded as hosts. Consequently there is a serious threat of its being accidentally introduced to the mainland.

CITRUS BLACKFLY INFESTS MANY PLANTS IN MEXICO

In Cuernavaca, Mexico, the citrus blackfly was found infesting 58 species of plants in 32 families in addition to citrus. Complete development of the blackfly was observed on 33 of the species.

POTATO PSYLLID BELIEVED TO SPREAD FROM SOUTHERN BREEDING AREA

Surveys of the breeding areas of the potato psyllid confirmed previous observations indicating that the spring breeding area in southwestern Texas may be the source of psyllids infesting potato and tomato fields as far north as Wyoming and Nebraska.

SURVEYS HELP SUGAR-BEET GROWERS REDUCE LOSSES

Surveys in winter breeding areas of the beet leafhopper were the basis of information supplied to sugar-beet growers on the expected magnitude and time of movement of the pest into cultivated areas in Idaho and Utah. These statements were of much value as guides to crop handling and planting in order to avoid serious losses from this pest.

FOREST PESTS CAUSE EXTENSIVE DAMAGE TO TIMBER

A survey late in the fall of 1946 disclosed that a serious outbreak of the Sitka spruce beetle, still in progress on Kosciusko Island in Alaska, has killed about 35.5 million board-feet of high-quality spruce. It is estimated that there are 17,700 million board-feet of Sitka spruce in Alaska, the finest stands occurring on this island. This is one of the country's most valuable specialty woods, being of great value in airplane construction. Information from the survey is being used by the Forest Service in planning logging operations to salvage at least a part of the killed timber.

Losses caused by the Engelmann spruce beetle in western Colorado since 1940 are now estimated at more than 3 billion board-feet. A fairly complete survey of the spruce areas in 1946 resulted in a reduction in previous estimates of losses, but showed that all but 2 percent of the volume of Engelmann spruce on most of the White River National Forest has been killed. The infestation also continues to be severe on the Grand Mesa National Forest. The most encouraging findings were that a substantial decrease in infestation occurred on the Routt, Holy Cross, San Juan, Montezuma, Gunnison, and Uncompahgre National Forests; that woodpeckers were exerting an important control force in all infestations; and that in all areas, except possibly on the White River Forest, the infestations were not enlarging. An important conclusion from the survey is that all stands of mature Engelmann spruce carry a rather high endemic infestation, presumably as a normal condition. This situation, plus the high rate of reproduction by the beetle, accounts for the rapid development of an outbreak following an extensive blow-down of timber, such as occurred in 1939.

Outbreaks of the Black Hills beetle increased sharply during the year in several areas. On the Roosevelt National Forest in Colorado a fall survey showed about 37,000 ponderosa pine trees to be infested. This outbreak is now equal in size to the outbreak that occurred on this forest 20 years ago. Severe outbreaks are also present on the Black Hills and Harvey National Forests in South Dakota, where 6,300 ponderosa pine trees were estimated to be infested, and on the Wasatch and Ashley National Forests in Utah, where over 30,000 ponderosa and lodgepole pine trees were infested.

An infestation of the mountain pine beetle in lodgepole pine, which started about 3 or 4 years ago on the Caribou National Forest in Idaho, has spread northward into the Targhee and Teton National Forests and is threatening the pine in adjacent forests and Grand Teton and Yellowstone National Parks. The infestation is now estimated to involve 150,000 trees infested in 1946 on the Caribou and 31,000 trees each on the Targhee and Teton Forests.

Bark beetle infestations in the pine stands of the Pacific Coast States continued to be spotty, with only a few areas where control was con-

sidered necessary. The situation was found to be less favorable in the extensive stands of valuable Douglas-fir in Coos and Douglas Counties in Oregon, where about 20 percent of the trees have been killed, mostly by the Douglas-fir beetle.

Considerable defoliation by the spruce budworm was found during 1946 in an area covering about 3,000 square miles in the Adirondack Mountains in New York. A much larger area is lightly infested as indicated by the accompanying map (fig. 2). Heavy moth flights into Vermont were observed in July. Elsewhere in the Northeast the bud-

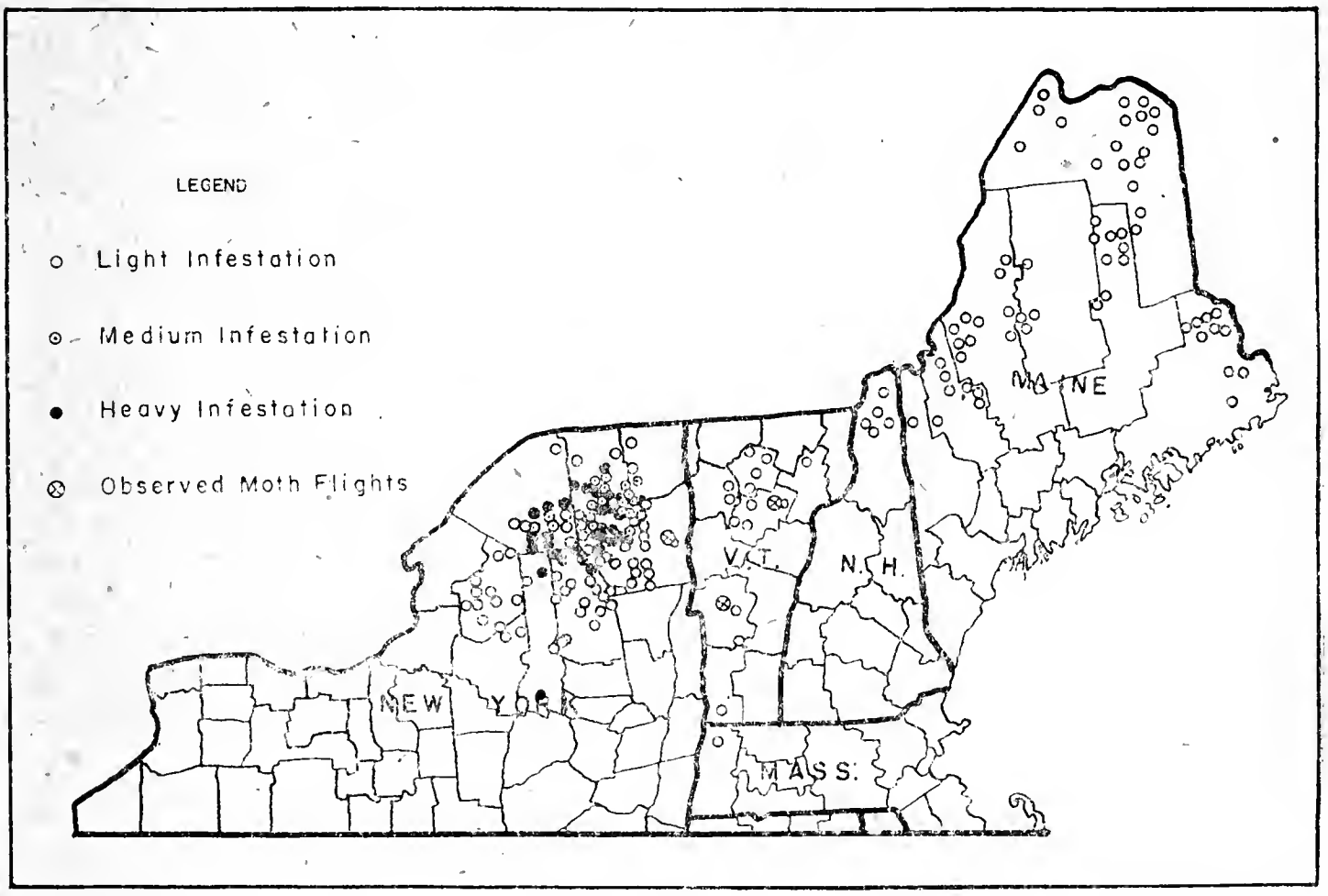

FIGURE 2.—Known distribution of the spruce budworms in 1946.

worm populations remained low, although there was an appreciable increase in four localities in Maine.

NEW LOUSE FOUND ATTACKING CATTLE

A sucking louse, *Haematopinus quadripertusus* Fah., called the tail louse, originally described from Africa where it is a pest of cattle, was found in this country for the first time in 1945, specimens having been taken on cattle in Florida. The species has since been found in several localities in that State and has also been identified from Texas and Alabama. It is considered among the most serious of the cattle lice. The adults congregate on the tail of the host, and the switch shows a matted appearance due to the large number of eggs deposited on it. The younger stages of the louse have also occasionally been found in the ears and elsewhere on the host. Little is known regarding the life history of this species, and further information is needed to establish its prevalence and distribution in the United States. Although the new louse appears to be more resistant to DDT than the related short-nosed cattle louse (*H. eurysternus* (Nitz.)), preliminary tests indicate that good control can be obtained by thoroughly applying high concentrations of DDT sprays.

EMERGENCY SURVEYS OF COTTON, TRUCK-CROP, AND FRUIT INSECTS CONTINUED

The emergency survey, conducted in cooperation with other agencies to determine the status of the important insect pests of cotton and the availability of insecticides needed for their control, was continued in 1946. Fifteen weekly reports on cotton-insect conditions in thousands of fields were issued from June through September. Unusually heavy infestations of boll weevils, bollworms, and cotton leafworms developed in parts of Texas, Louisiana, and Arkansas, and large quantities of calcium arsenate and other insecticides were required. At times the supplies of insecticides were limited, especially in Louisiana and southern Arkansas. The survey reports helped make it possible for all cotton-growing areas to obtain adequate supplies in spite of local shortages. They also furnished other information to farmers, county agents, extension entomologists, and others interested in the growing of cotton.

The cooperative emergency survey of truck-crop insects and requirements for their control was continued throughout the year. Survey statements, issued each week to the insecticide industry and interested organizations and individuals, were of considerable aid in bringing about effective distribution of scarce insecticides.

Similarly issued during the 1946 crop season were 19 weekly reports relative to the current status of fruit insects controlled by nicotine, as an aid to obtaining equitable distribution of limited supplies of nicotine insecticides for protecting fruit crops. The cooperative emergency survey of fruit insects was resumed in April 1947, attention during this crop season being given to the status of fruit insects in general in view of the scarcity of other needed insecticides as well as nicotine.

BIOLOGICAL STUDIES PAY DIVIDENDS

KNOWLEDGE OF EGG-LAYING HABITS MAY AID CONTROL OF DEER FLIES

Studies were continued on the biology of the deer fly (*Chrysops discalis* Williston), which breeds in large numbers in the vicinity of Summer Lake, Oreg. The most significant finding was the observation that, in addition to ovipositing on plants along the lake margin, the deer fly deposits large numbers of eggs on objects above the water line, such as sticks, stones, and wire. On one board having 3 square feet of surface about 10,000 egg masses were deposited in 2 days. This egg-laying habit may lead to effective ways of reducing deer fly populations. Insecticides may be applied to "egg traps" placed in the lake to kill the eggs or the flies that are attracted for oviposition.

METHODS IMPROVED FOR MAINTAINING LOUSE AND CHIGGER COLONIES

During the year the body louse colony, previously maintained on man at the Orlando, Fla., laboratory for about 5 years, has been reared exclusively on rabbits. In addition to saving manpower, this method has made possible certain investigations which could not be undertaken when it was necessary to use man as the host of the colony.

A thriving laboratory colony of chigger mites (*Eutrombicula* spp.) has also been established. The method employed was adapted from technique developed by the Chemical Warfare Service. Cold-blooded animals, such as turtles, are used as hosts for the larvae, and eggs of *Aedes aegypti* serve as food for nymphs and adults.

INSECT IDENTIFICATION OF FUNDAMENTAL IMPORTANCE

Accurate and prompt identification of insects is basic to all sound entomological activities. It is essential for the application of correct control measures, for the determination of extensions in the distribution of established insects to new areas, for the detection of pests new to the country, and to obtain information as to their source. During the year such identification service was provided for 58,612 insect samples. These identifications were made for workers in this Bureau engaged in research, control, quarantine, and survey activities; for the Army, Navy, Public Health Service, and other Federal agencies; for agricultural colleges and experiment stations of every State, Puerto Rico, Alaska, and Hawaii; for individuals, private institutions, and pest-control operators; and even for foreign governmental agencies and institutions.

New pests identified included a weevil of the genus *Phyllobius* found damaging ornamental evergreens in Rhode Island; a leaf beetle of South American origin, commonly referred to as the cabbage leaf beetle, found on cabbage, turnip, and related plants in a limited area of Alabama; and the mango fruitfly, which apparently became established in Hawaii during the exigencies of Pacific warfare. Identification of these pests made it possible to determine promptly the foreign countries of origin, which is of special importance in indicating the home of possible natural enemies that may be obtained to combat the injurious forms, or in the tightening of quarantine restrictions.

One taxonomist in the Bureau participated for 6 months during 1946 in an economic survey that the Navy was conducting in the central Pacific island groups—the Marshalls, Marianas, and Carolines—that were formerly mandated to Japan. Approximately 25,000 insects were collected and submitted for identification. The species of obvious importance as pests were segregated and promptly identified so that control investigations might be undertaken, where necessary, without delay.

Less than one-fourth of the existing species of insects in the world are known, and less than 3 percent are currently identifiable in their immature stages. Accordingly, continuing research in insect classification is essential for the gradual improvement of the identification service. During the year such research was conducted intermittently by each specialist insofar as service tasks permitted. Thirty-six technical manuscripts covering specific taxonomic problems in all major insect groups were completed and submitted for publication.

A large-scale research project undertaken during the year involves the redefinition of the Meyrick species of Lepidoptera. This work is basic to accurate identification in this large group, which contains numerous serious agricultural pests. The Meyrick collection is at the British Museum of Natural History; accordingly the Bureau specialist on Microlepidoptera has been assigned to work in London for the duration of this study.

RESULTS OF BUREAU WORK MADE AVAILABLE THROUGH PUBLICATION

There has continued to be a great demand for information concerning the work of the Bureau, particularly with regard to developments in new and improved materials, methods, and equipment for controlling insect pests. During the year 79 manuscripts prepared by Bureau personnel were approved for publication in the printed or

processed series of the Department or Bureau and 376 for publication elsewhere. The total represents an increase of 23 percent over the number approved during the previous year. Numerous BEPQ circulars and other publications announcing changes and additions to plant-quarantine regulations were issued as required by law. Several leaflets and other printed publications were revised to include recommendations for the use of DDT, especially for the control of household pests.

A popular publication entitled "DDT for Control of Household Pests" was issued jointly by this Bureau and the United States Public Health Service. Lack of adequate printing funds made it necessary to limit the stock of free copies on this highly popular subject, but copies are available from the Superintendent of Documents.

Six colored picture sheets on important insect pests of cotton were issued, and have been in great demand.

About 647,000 copies of printed publications and a considerable volume of processed material on general entomological subjects, as well as 114,000 copies of quarantine regulations, service and regulatory announcements, BEPQ circulars, and miscellaneous regulatory publications were distributed during the year. Additional information on subject matter pertaining to the work of this Bureau was contained in 102 press and 52 radio releases, 37 feature articles, 17 articles for the USDA Yearbook, 5 for other yearbooks, and 7 miscellaneous articles, which were approved for release during the year.

CONTROL PROJECTS

SUBSTANTIAL PROGRESS MADE IN GYPSY MOTH CONTROL

Gypsy moth larvae caused from 25 to 100 percent defoliation in more than 622,000 acres of woodland in 1946. This was 200,000 acres less than in 1945, the year of greatest defoliation by this insect on record. Although the larvae fed normally, there was heavy mortality just before or soon after pupation, resulting in a substantial reduction in the number of egg clusters deposited.

In 1947 eggs began to hatch about May 13, approximately 11 days later than usual in southern Vermont and New Hampshire, Massachusetts, and northern Connecticut; and about 18 to 21 days later in southern Connecticut and in Pennsylvania. Egg clusters collected in 55 towns in New York and New England, and in 8 towns in Pensylvania showed on an average a 74 percent hatch. This is about normal, although somewhat higher than in the previous 2 years. The winter of 1946–47 was not abnormally cold, and there was little mortality of egg clusters.

USE OF SEX ATTRACTANT IN SURVEY TRAPS EXTENDED

During 1946 more than 6,184,000 acres of timber in and adjacent to known infested areas in New York and Pennsylvania were surveyed with 11,744 traps at a cost of approximately 1 cent per acre. The area around each trap that caught male moths was searched for egg clusters, and the information thus acquired provided a basis for planning the 1947 spray program.

Over 1,320,000 female pupae were collected and processed during 1946 for the 1947 trapping program, about 300,000 more than in any previous season. However, only 22 percent of the females emerged,

probably owing to unseasonably cold weather during the critical period of pupation.

AIRPLANE APPLICATION OF DDT HIGHLY EFFECTIVE

In selecting areas for treatment in Pennsylvania in 1946, priority was given to those which because of location or degree of infestation constituted the greatest hazard of spread. Some infested areas contained 4,000 egg clusters or more per acre at the time DDT was applied.

About 39,500 acres were carefully examined after the spraying and only 12 egg clusters were found. They were in areas sprayed late in June when the larvae were full grown. It is generally assumed, therefore, that the few surviving larvae had begun to pupate before the spray was applied and for that reason did not come in contact with the DDT.

In the spring of 1947 approximately 162,800 acres of infested timber were sprayed in Pennsylvania, New York, and New England. This is about double the acreage sprayed in 1946. All insecticides used in Pennsylvania and New York were purchased by the States as a part of their cooperation in the program. The State of New York supplied two airplanes and pilots and some ground spray equipment. Aircraft, mist blowers, and knapsack sprayers were used in dispensing the insecticides.

In Pennsylvania 20,000 acres were sprayed under contract at a cost of approximately 68 cents per acre for application only.

During the last 2 seasons, approximately 243,000 acres of timber infested with gypsy moths have been sprayed with DDT at the rate of 1 pound in 1 gallon of solution per acre prior to hatching, and one-half pound per acre after the eggs hatch. The results have been such that there is now good reason to believe that the isolated infestation in northeastern Pennsylvania involving about 100 square miles, may be eradicated within the next few years and that we may expect steady progress toward eliminating infestation west of the Hudson River in New York.

DETECTION AND CONTROL OF INCIPIENT JAPANESE BEETLE INFESTATIONS

In order to detect incipient Japanese beetle infestations outside the regulated areas, approximately 45,000 traps containing attractive chemicals were set out in 1946 at 668 points in 39 States. No traps were set in the seven States largely or entirely under regulation, or in Arkansas and Nevada. In general, the traps in cities not known to be infested were placed near transportation terminals, where hitch-hiking beetles might be caught. Traps were placed at 200 airfields in 36 States because of the menace of beetle spread by airplane. Army and State officials cooperated with Bureau workers in the placing and tending of the traps, especially in the Western and Southern States. Beetles were caught at airports at Miami and Valpariso, Fla., Charleston, S. C., and Nashville, Tenn., and 1 beetle was taken at Fort Madison, Iowa, which is not near any known infested area. Evidence of an established infestation was found at Alderson, W. Va., 125 miles from a previously known infested area. From 1 to 23 beetles were caught at 20 other trapping sites nearer known infested areas.

During May and June 1947 about 12,000 traps, representing only a portion of the number to be used in the 1947 trapping program, were placed at 200 locations in 15 States. Another beetle was caught at

the airport in Miami, Fla.; from 1 to 53 beetles were taken at 2 locations in Georgia, 12 in North Carolina, and 5 in Virginia, all being previously known infested sites.

In addition to the trap surveys around airfields in 1946, inspectors at four large airports in the infested area examined the interiors, baggage, and passengers of 4,535 planes. Airport personnel gave aerosol treatments to 3,654 planes prior to their departure. Operational and experimental applications of DDT were made at the Washington National Airport to reduce the chances of beetles entering airplanes while being loaded.

Prospects for suppressing or eradicating small infestations of Japanese beetles in outlying areas have been improved by the use of DDT as a soil-surface treatment, a procedure authorized in July 1946. This insecticide was applied to 207 acres at 9 locations in Georgia, Missouri, New York, North Carolina, and Virginia, and lead arsenate to 321 acres at 15 locations in Georgia, Illinois, Indiana, Michigan, Missouri, Ohio, and Virginia. The figures include 459 acres treated at previously treated locations, and 69 acres at new locations. The Bureau furnished equipment and operators, and the State agencies supplied the insecticides.

DDT was also applied to foliage at 15 locations in Georgia, South Carolina, North Carolina, Ohio, and Illinois as a means of checking incipient infestations.

GRASSHOPPER CONTROL PAYS 40 TO 1

An estimated 2,507,000 acres of land were baited in the grasshopper-control program conducted in 1946 in cooperation with State and county agencies in 21 central, midwestern, and western States. More than 30,000 farmers and ranchers in 423 counties participated in the program, spreading 15,812 tons (dry weight) of bait furnished by the Federal Government. The Bureau financed the spreading of an additional 925 tons of bait on roadsides, irrigation canal banks, and rights-of-way; other Federal agencies spread 284 tons on lands under their jurisdiction. This program afforded protection from grasshoppers to more than 5,765,000 acres of crop and pasture lands valued at over $41,150,000. The savings amounted to approximately $40 for each dollar expended.

Surveys conducted in the fall and early winter of 1946 indicated that the infestation to be expected in 1947 would be about the same as that which developed in 1946. An adult survey was made in 643 counties in 22 States, and an egg survey in 266 counties in 13 States.

The weather in the spring of 1947 was favorable to a rapid hatching and development of grasshoppers only in Arizona, California, Texas, and certain areas west of the Continental Divide. In the northern Great Plains States hatching of economic species was very light prior to June 1. Light to threatening infestations occurred in 1947 in Arizona, California, Montana, Colorado, Nebraska, Kansas, South Dakota, Wyoming, Minnesota, Texas, Utah, Idaho, Illinois, Michigan, Missouri, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, Washington, and Wisconsin. Areas of threatening infestations increased slightly in Colorado, Kansas, Minnesota, and Texas, and in South Dakota the area requiring control shifted eastward from the western portion of the State.

The amount of bait used in 1947 is expected to equal or slightly

exceed in amount that spread during 1946 if weather conditions are not too unfavorable for grasshopper development, crop growth, and baiting activities. By June 21, 1,737 tons (dry weight) had been mixed in all States, 700 tons less than had been mixed at the same time in 1946. This decrease indicates a delayed rather than a lessened use of bait in 1947.

BAITS PROTECT CROPS FROM MORMON CRICKETS IN NORTHWEST

In 1946 the Federal Government financed the spreading of 1,654 tons (dry weight) of bait in 15 counties in Idaho, Nevada, Oregon, and Washington for control of Mormon cricket infestations. The control work was undertaken cooperatively with the States, and in 2 of the counties other Federal agencies as well as individuals took an active part. Over 225,000 acres were baited, affording protection to 121,000 acres of crop and pasture lands as well as to large range areas. Most of the work was accomplished on range infestations distant from and therefore not constituting a serious threat to cultivated areas. About 20 percent of the bait was spread by airplane, 4 percent by hand, and the remainder with ground-baiting equipment.

Surveys to determine the population of adult Mormon crickets in 36 counties in 7 States late in the summer of 1946 indicated that infestations would be more extensive in 1947. In Idaho, Nevada, Oregon, and Washington the infested areas were almost twice as large as they were in 1946. However, since most of the infestations were on range lands away from cropped areas, crop damage was expected to be light. In 1947 operations were begun in Oregon late in March, in Nevada and Washington in mid-April, and in Idaho in mid-May. By June 21 Bureau crews had spread 874 tons of bait on 166,000 acres, and farmers, ranchers, and other cooperators had spread an additional 251 tons on 44,000 acres in Oregon and Washington.

CHINCH BUGS REQUIRE LITTLE CONTROL

During 1946 chinch bug incidence was very low in the normally infested Central and Midwestern States. A limited amount of barrier control in Illinois, Kansas, Missouri, Nebraska, and Oklahoma halted the depredations and protected about 11,000 acres of crops valued at $77,000. Approximately 15,000 rods of barriers were erected and maintained by 230 farmers, using 15,000 gallons of creosote oil and 2,300 pounds of dinitro-*o*-cresol dust furnished by the Federal Government.

Fall and early winter surveys conducted in 160 counties of 6 States indicated that, unless weather conditions in the spring and summer were unusually favorable to chinch bug development, an outbreak in 1947 was not probable. By June 21 weather conditions had been so unfavorable that it appeared that few barriers would be needed.

LITTLE BAITING NEEDED TO CONTROL ARMY CUTWORMS

Army cutworms required control during 1946 in only a few localities in Colorada, Nebraska, Oklahoma, Utah, and Wyoming. Forty-three tons of bait were spread by about 100 farmers on 2,600 acres of crop and pasture lands, mostly in Colorado. Infestations requiring a small amount of control developed during the spring of 1947 in scattered

localities in Colorado, Idaho, Montana, Nebraska, Oklahoma, Texas, and Wyoming.

MANY NEW WHITE-FRINGED BEETLE INFESTATIONS FOUND

The discovery of white-fringed beetle infestations, apparently of long standing, in two Georgia nurseries was mentioned in the report for 1946. This discovery, followed by the finding of beetles at several planting sites of stock from these nurseries, emphasized the importance of nursery stock as a means of spreading these beetles. Surveys and inspections, heretofore essentially directed to lines of travel and commodities moving from infested areas, were therefore expanded to include nurseries throughout the Southeast and planting sites of stock

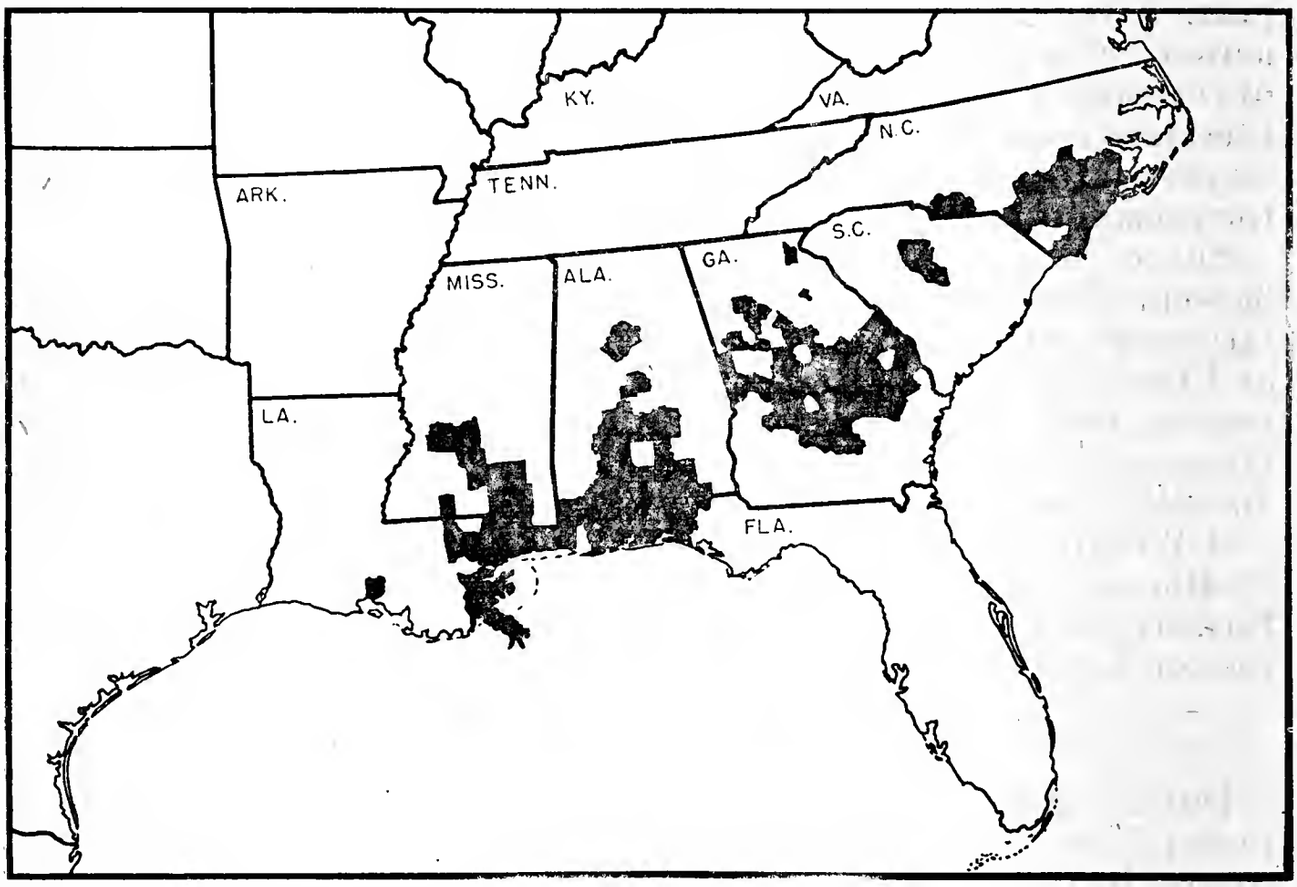

FIGURE 3.—Counties infested with white-fringed beetles, by States, through June 30, 1947.

from the infested nurseries in the eastern half of the United States. By the end of June 1947 infestations had been found at 85 locations in 51 counties in Georgia and at 2 locations each in South Carolina and Alabama, all of which had evidently resulted from movement of stock from the infested nurseries. Planting sites of such stock in 23 States and the District of Columbia were found to be apparently free of infestation.

During the year additional infestations were found in Alabama and Mississippi in small areas adjacent to previously known infested areas. In May 1947 an extensive infestation was discovered at Birmingham, Ala., and in June white-fringed beetles were found for the first time in Santa Rosa County in northwestern Florida. White-fringed beetles are now known to be present on approximately 200,000 acres in 7 States, as shown in figure 3.

Treatments for control of the white-fringed beetles were restricted primarily to locations where they were considered essential for reduc-

tion of populations and in situations presenting a hazard of long-distance or important local spread. For these purposes herbicide sprays were applied on 445 acres, 31,805 acres were treated with DDT in various formulations, and 7,021 acres with cryolite spray or dust. In addition, cyrolite was applied to 3,578 acres by airplane. Many improvements were made in methods of inspection and control and in insecticide formulations and mechanical devices for their application, as a result of technical studies conducted by the Bureau.

PROGRESS MADE IN SWEETPOTATO WEEVIL CONTROL AND ERADICATION

During the war years and immediately thereafter production of sweetpotatoes increased greatly throughout the Southern States. Production of seed stock certified free of sweetpotato weevils could not keep pace with demands, and many plants were used from uncertified or infested sources. Increased demands for sweetpotato table stock and sweetpotatoes for processing resulted in irregular interstate movement of considerable quantities from infested fields or storages. Funds and personnel were inadequate to prevent some movement of infested stock contrary to State quarantine restrictions. These factors are believed to be largely responsible for new infestations found in 7 counties in Georgia late in 1945 and early in 1946, including highly important sweetpotato-plant-producing areas; for infestations found in Charleston County, S. C., in 1946; and for a considerable increase in the number and intensity of infestations in the sweetpotato-producing area of central Louisiana, where most of the commercial sweetpotatoes grown in the Southern States are produced.

The problem of sweetpotato weevil control is now being attacked more aggressively. Federal funds and State cooperation were increased for this year. Intensive surveys were made to delimit known new infestations and to discover any additional incipient infestations that might be present in commercial producing areas. From April 1, 1946, to March 31, 1947, 73,091 inspections were made of fields, seedbeds, and storage places in Alabama, northwestern Florida, Georgia, Louisiana, Mississippi, South Carolina, and eastern Texas. Measures taken for weevil eradication on 918 farms in 35 counties during that period have apparently been successful, and these farms have been released from planting restrictions. In the important sweetpotato plant-producing areas of Georgia the weevils have apparently been eradicated on approximately 80 percent of the farms found infested since 1945.

Since 1937, when the cooperative Federal-State program was begun, weevils have apparently been eradicated from 6,489 properties, or nearly 75 percent of the total number found infested. As of the end of March 1947 infestation was known to occur on 2,325 farms.

Assistance has been given in the enforcement of State regulations pertaining to the movement of sweetpotatoes and sweetpotato plants. Changes have been made in the State regulations to prevent more effectively the interstate movement of infested material, particularly unfumigated potatoes from the heavily infested area of central Louisiana.

The practicability of using DDT for eliminating weevils from seedbeds, fields, and stored potatoes is being investigated through practical field and storage tests.

PEAR PSYLLA INFESTATIONS INCREASE IN NORTHWEST

Intensive surveys late in 1946 and during the winter and early spring of 1947 revealed a big increase in the number of properties infested with pear psylla in the important commercial pear-growing areas of Washington, but little increase in the size of the general area known to be infested. Sticky-board traps exposed during the period of greatest psylla abundance, late in the summer and during the fall were inspected during the winter. Sticky bands were exposed on the trunks of the trees late in the fall and during the winter, to capture hibernating psyllas, and were examined during the spring. Traps and bands exposed in the Wenatchee Valley revealed infestation on about 88 properties, involving 44,000 pear trees. Infestation was also found on 8 properties in Yakima County, 6 of them a few miles north and northwest of Yakima and 2 in the Grandview section.

The distribution pattern and lightness of the recently discovered infestations strongly suggest that most of them are of recent origin and have resulted from wind spread, perhaps from a considerable distance.

With pear psylla occurring in these important commercial pear-growing areas, the increased number of trees involved, and the scarcity of nicotine, the 1947 control program was modified to provide materials for applying two summer sprays to infestations found in commercial orchards since completion of the 1946 spray program. The survey work was limited to the exposure of about 75,000 sticky-board traps to give information on the status and distribution of the insect in the Yakima and Wenatchee-Okanogan areas. While this means that the original objective, which was to prevent the establishment of the pear psylla in the important commercial areas of the Northwest, must be abandoned, the history of the program will show that cooperative control work undoubtedly delayed by several years the spread of the pear psylla to the Wenatchee and Yakima Valleys. This gave protection to the pear industry of the West at a time when labor, spray equipment, and insecticides were of inferior quality or in inadequate supply. Time was also gained to permit a search for new materials to replace or supplement scarce nicotine, and promising substitutes are now being developed.

FUMIGATION PROGRAM AGAINST HALL SCALE INTENSIFIED

In the fumigation program against the Hall scale, which occurs in a limited area near Chico, Calif., 10,821 trees were treated with hydrocyanic acid gas during the 1946–47 season, or approximately 68 percent of the trees in the area. This compares with 1,522 trees so treated the previous season. Postfumigation examination of samples of twigs from 157 of the prune and almond trees fumigated during the previous season showed infestation on but 2 of them. Only a single living scale was found in each tree, and both trees were adjacent to nonfumigated trees. The oil-spray program, involving two annual applications, was continued during the year, supplementary to the fumigation program. The California Department of Agriculture continued to cooperate in the program.

Continuation of the intensive survey and inspection program revealed no important extension of the infested area, and no new infestations in either outlying or distant areas. The infestation at Oroville, Calif., where 83 plants were found infested on 22 properties in 7 blocks, all in a compact group, has now been delimited.

Inspections in several Western States of properties that received Hall scale-susceptible nursery stock from the United States Plant Introduction Garden in earlier years did not disclose any infestation by this insect.

CONTROL OF DOG FLY ANNOYANCE AT ARMY AIR FORCE CAMPS CONTINUES

For the sixth successive season the Bureau has cooperated with the Army Air Forces and the Public Health Service in suppressing the dog fly nuisance in and around the Army Air Forces training bases in the Gulf coast area of north Florida. Swarms of these persistent flies reduce training efficiency and affect personnel morale.

In the absence of satisfactory repellents, the purpose of the campaign as presently conducted is to prevent fly propagation in the chief breeding grounds, the beach-grass deposits, by spraying this debris with DDT regularly throughout the breeding season. Cheap and efficient application has been developed through the use of shallow-draft, air-propelled swamp gliders, with a device which draws in sea water automatically, mixes a DDT-xylene emulsion concentrate with it, and pumps the emulsion continuously through buoyed hose to nozzles at the beach windrow deposits.

This spraying program, carried out from July 9 to October 31, 1946, involved six spray applications along 120 miles of the Gulf coast. In the season's operations 143,673 gallons of spray were used on 1,043 miles of grass deposits, or 137 gallons per mile. Improvements in application methods made it possible to do the same work with three gliders that was previously accomplished with five.

Suppression of dog flies in and around the training camp has been again satisfactory, as determined from camp personnel experience and as checked by dog fly counts on dairy cattle both within and outside the protected area. Bureau participation in this war emergency non-agricultural pest-control work was terminated on June 30 by agreement with Army Air Forces.

COOPERATIVE PROGRAM TO CONTROL TUSSOCK MOTH OUTBREAK

An outbreak of the Douglas-fir tussock moth under observation in the late summer and fall of 1946 threatened to cause serious damage in 1947 to about a half-million acres of valuable timber in the Northwest. This area included Federal forest lands and adjacent timber holdings under State and private ownership. To protect any given area adequately it was necessary that adjacent infested areas also be treated. Thus, cooperative action by all agencies concerned was essential.

Federal, State, and private funds totaling more than $600,000 were made available for organizing and carrying out control measures to meet this emergency. The Forest Service was responsible for administrative supervision of the project, and the Bureau of Entomology and Plant Quarantine for its technical planning and direction. The insecticide applications were made by two commercial airplane companies, under contract.

The operation, which involved the application of DDT sprays by airplane to 413,469 acres of timberland, much of which was in mountainous country, was further complicated by the necessity of completing the job within a few weeks while the young caterpillars were feeding.

From the time the spray applications were begun on May 22, 1947, until the entire control area had been treated on July 2, 390,881 gallons of insecticide were dispersed at the rate of approximately 1 pound of DDT in 1 gallon of solvent per acre. In all, 2,120 airplane flights were made in treating 395,535 acres in Idaho, 13,559 acres in Oregon, and 4,375 acres in Washington. In addition to several small planes, large planes of the C–47 and Ford tri-motor types were used in dispersing the insecticide. Inspections made shortly after the spraying disclosed no living tussock moth caterpillars in the treated area.

EFFORTS CONTINUED TO CONTROL AND PREVENT SPREAD OF GOLDEN NEMATODE

Regulatory measures to prevent the spread of the golden nematode were carried out during 1946 in cooperation with the New York State Department of Agriculture and Markets. Surveys to discover new infestations of this pest of white potatoes were continued on lands adjacent to the known infested area in Nassau County, on Long Island, and in adjoining Suffolk County. Reduction of nematode populations in known heavily infested fields was undertaken through the treatment of infested lands with a soil fumigant to lessen the hazard of spread. Cooperative assistance was extended to the Bureau of Plant Industry, Soils, and Agricultural Engineering and to Cornell University in their research investigations on this nematode.

The 1,081 acres of land known to be infested at the beginning of 1946 were taken out of potato production under the program established by the New York State Department of Agriculture and Markets. After the spring planting, however, an additional 1,600 acres, most of which was already planted to potatoes, was revealed by the survey to be infested with golden nematode. The potatoes produced on this acreage offered a difficult marketing problem. Through the production and marketing program 112 carlots were moved to Kentucky, Illinois, and Pennsylvania for processing at alcohol plants. The remainder was disposed of for consumption within New York City at military installations or at food-processing plants.

During the calendar year 1946, 14,245 acres of farmland were surveyed in Nassau County and 11,117 acres in Suffolk County. In Nassau County 1,595 acres were found infested for the first time, bringing the total known infested area to 2,676 acres. No infestations were found in Suffolk County.

A soil-wash method for the detection of golden nematode cysts in soil samples was developed in 1946. Use of this new method permitted extension of the survey program in efforts to discover the limits of the infestation.

Treatment was given to 1,557 acres by applying the fumigant D-D, 6 inches below the soil surface. Five tractor-mounted applicators were especially designed and constructed for this purpose. Each machine treated 15 acres per day with 450 pounds of D-D per acre.

POTATO ROT NEMATODE NOT FOUND IN 15 POTATO-GROWING STATES

A survey was conducted during the year, in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the various States concerned, to determine whether the potato rot nematode has become established in the potato-growing areas of the northeastern quarter of the United States. This nematode was found

in a limited area in the vicinity of Aberdeen, Idaho, in 1943, at which time steps were taken by the State to prevent further spread of the pest. In 1945 it was reported in some of the fields on Prince Edward Island, Canada, from which seed potatoes had been shipped to the United States. Such shipments as could be located were condemned for seed purposes.

The current survey was conducted in 85 counties in Connecticut, Maryland, Maine, Michigan, Minnesota, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, and Wisconsin. Inspections were begun in July and extended into the storage period. Examinations for tubers showing suspicious lesions were made at 331 sites on potatoes in more than 2,100 fields, barns, cellars, grading rooms, cull piles, and storage places. Two hundred and sixty-seven lots of specimens were submitted to State identification centers or to the Bureau of Plant Industry, Soils, and Agricultural Engineering for identification, but no evidence of potato rot nematode was found.

DUTCH ELM DISEASE CONTINUES TO SPREAD

SCOUTING CARRIED ON IN OLD AND NEW AREAS

Scouting to locate diseased trees within the known limits of Dutch elm disease distribution was carried on in eight States cooperating in the control program. More than 750 of the elm cuttings collected yielded the disease fungus when cultured. These finds added 63 new localities to the known infected area. Large increases in infected areas were found in western Massachusetts and in Indiana near Indianapolis, but only 20 diseased elms were discovered in Vermont, Rhode Island, Delaware, and Virginia. In Connecticut the territory west of the Connecticut River and in Maryland Frederick County were excluded from the scouting because the disease incidence was high; there was little increase in infected trees in the portions of these States that were worked.

During July, August, and September 1946 and May 1947 rapid surveys were made well beyond the known limits of the disease in 7 infected States and in 19 States in which infection was not known to occur, this area being largely east of the Great Plains. The Dutch elm disease fungus was isolated from elm cuttings taken in Jackson County, Mo., and in Hardeman, Smith, and Wilson Counties, Tenn. The European elm bark beetle was found for the first time in 149 counties in 16 States. One beetle was taken 250 miles west of previously known limits. Symptoms of phloem necrosis, a virus disease that kills elms and thereby makes material suitable for bark beetle breeding, were found for the first time in 33 counties and 7 States. One suspected location for this disease is 150 miles southwest and one 200 miles southeast of earlier known cases.

During the year more than half of 26 small study centers around diseased trees under observation since 1943 showed increases in Dutch elm disease incidence. Decreases were recorded in centers where the number of elms had been drastically reduced by the disease in previous years.

Rhode Island became the fourteenth State known to be invaded by the Dutch elm disease, when one diseased tree was found northwest of Providence. In June 1947 an infected tree was found in Washing-

ton, D. C. The disease had been found 20 miles away in Maryland earlier in 1947. The known infected area at Indianapolis, Ind., doubled the size it had reached during the eight previous years. Diseased trees were found for the first time in southeastern Indiana, extending from the large infected area in southwestern Ohio. In New York the disease was found within 14 miles of Lake Ontario, at a point 100 miles north of the generally infected area around Binghamton. The known area of disease infection in the Hudson Valley was extended northward 50 miles during the year to within 88 miles of Canada.

INFECTIONS DISCOVERED IN TWO NEW AREAS

The discovery of 21 diseased trees in 7 towns in Norfolk, Plymouth, and Bristol Counties, Mass., brought the area around Boston within the known limits of Dutch elm disease distribution. The disease appears to be well established in Quincy. The State and the towns concerned acted promptly to remove diseased trees found by Federal scouts. The European elm bark beetle has been known to occur in this area for 40 years.

Trees infected with Dutch elm disease were found this year in 9 counties in northeastern Ohio. The area of known infection extends 67 miles from Cleveland eastward to the Ohio-Pennsylvania State line and 76 miles southward to the Ohio River at East Liverpool. The greatest disease intensity is at the geographic center of this 5,000 square mile area. Between 1930 and 1935 thirty-three infected trees were found in the Cleveland section, but after thorough eradication work the disease did not appear again until 1946. The European elm bark beetle invaded this area in 1944.

DISEASE-IDENTIFICATION LABORATORY

More than 7,250 specimens taken from trees suspected of being diseased were cultured in 1946 to determine the possible presence of the Dutch elm disease fungus. Of these, 5,600 were collected by survey workers; 1,200 came from the experimental plots; and over 450 were sent in by State officials, tree wardens, arborists, and property owners. The specimens came from 30 States and the District of Columbia. The fungus was isolated from 2,242 specimens.

Special studies were made to improve the chances of obtaining and identifying the disease organism, if present, especially in dead and bark beetle-infested materials. Significantly more positive results were obtained by increasing the number of culture plates made of such material, and by changing the incubation procedure. Increased attention was given to the various forms of the disease and of related species, which can be identified positively only by close study.

RESULTS OF WORK IN EXPERIMENTAL CONTROL PLOTS

Scouting and sanitation work were continued in two experimental plots in New Jersey within areas heavily infected with Dutch elm disease and in one plot in a lightly diseased area in Ohio. The object was to test the effectiveness and practicability of such control work in a local area. The amount of the disease found in one New Jersey plot was about the same as in the previous year, and in the other plot there was a 25 percent reduction. In both plots about 3 percent of the elms have become diseased in 3 years, whereas in a nearby plot where

no control work was done the disease has affected 10 percent of the elms during the same period. In the Ohio plot 9 diseased trees were found in 1945 and 54 in 1946, but the disease is still very light. The results indicate that losses due to the disease can be kept to a reasonable minimum by thorough scouting and sanitation. However, the high cost of thorough and timely work, together with the necessity of conducting operations on many private properties, emphasizes the need for developing more practical control methods.

In 1946 a 2-percent DDT emulsion was applied to 500 elms at four locations in the section of heavy disease incidence in New Jersey. Two applications were made, in May and in July. In 1947 the treatment was repeated on twice as many trees, and the spray strength and frequency of application were varied between plots. Preliminary results indicate that elm bark beetles will not feed on elm twigs so sprayed. The same spray applied at the same time to dead and dying elms also seemed to reduce the bark beetle population. Leaf-feeding insects are also readily controlled by such spraying.

COOPERATIVE ACTIVITIES CONTINUE IN CONTROL OF PHONY PEACH AND PEACH MOSAIC DISEASES

The Bureau and cooperating State agencies continued their activities to prevent spread of phony peach and peach mosaic diseases in nursery stock, to eliminate the diseases from lightly infected States and areas, and to suppress them in commercial orchards in the more heavily infected portions of Alabama and Georgia.

During the calendar year 1946 inspections were made in 217 nurseries growing more than 4 million peach trees, and in 50 proposed budwood sources and their 1-mile environs, all within areas regulated because of these virus diseases. Only 2 nurseries failed to meet requirements of the phony peach quarantines and 8 nurseries the requirements of the peach mosaic quarantines relating to interstate shipments. One budwood source was not certified. As a precautionary measure 194 nurseries with more than 10 million trees in formerly infected areas or adjacent to infected areas were inspected because their business involved extensive interstate shipments.

Orchard inspection for these diseases in 1946 was made in 209 counties in 15 States, involving over 10.5 million trees on more than 55 thousand properties. No disease was found for the third consecutive year in 14 counties, which are therefore eligible for release from quarantine. In the phony peach area 83,251 trees were found infected with this disease in the counties inspected. In the peach mosaic area 5,919 trees were found infected. All but a few of these diseased trees were removed.

Since 1937, when control of the phony peach disease was begun, infected trees have been found in 17 States. In 7 of these States, however, work was discontinued after no infected trees had been found for three consecutive years. In 7 other States the incidence of the disease decreased from 13,415 trees in 1936 to 1,727 in 1946. No diseased trees were found in Missouri in 1946. In the heavily infected portions of Alabama and Georgia inspection and destruction of diseased trees are apparently preventing material increases in disease incidence in commercial orchards but growers must organize for a prompt and vigorous community-wide diseased-tree removal program if they expect to reduce their current losses appreciably.

PROGRESS IN BARBERRY ERADICATION DURING 1946

Increases in Federal and State funds available for barberry eradication work during the 1946 season resulted in greater protection to grain from stem rust. From July 1 to December 31, 10,633 more square miles were worked and 1,753,109 more barberry bushes destroyed than during the corresponding period in 1945. On 6,609 properties that were reworked no new barberry growth was found, and 1,925 will require no future attention. As a result of the 1946 work 28,835 square miles were placed on maintenance and will require no further organized crew work. A summary of the barberry eradication work by States is shown in table 1.

TABLE 1.—*Results of barberry eradication work, calendar year 1946*

State	Area surveyed	Properties cleared		Bushes destroyed		
		New	Old	*Berberis vulgaris*	Native species[1]	Total
	Square miles	*Number*	*Number*	*Number*	*Number*	*Number*
Colorado	312	9	69	26	871, 745	871, 771
Illinois	527	26	136	868	6	874
Indiana	200	14	46	156	2, 523	2, 679
Iowa	373	24	136	982	0	982
Michigan	5, 603	150	219	5, 897	0	5, 897
Minnesota	661	10	26	234	0	234
Missouri	297	13	11	414	0	414
Montana	480	1	4	223	0	223
Nebraska	592	5	6	750	0	750
North Dakota	280	0	3	22	0	22
Ohio	464	47	47	2, 209	0	2, 209
Pennsylvania	0	29	597	24, 755	0	24, 755
South Dakota	4, 402	3	9	31	0	31
Virginia	106	76	141	0	7, 257, 971	7, 257, 971
Washington	2, 756	318	20	8, 212	0	8, 212
West Virginia	58	12	69	329	5, 365, 986	5, 366, 315
Wisconsin	4, 692	56	211	1, 734	0	1, 734
Wyoming	127	14	4	131	0	131
Total	21, 930	807	1, 754	46, 973	13, 498, 231	13, 545, 204

[1] *Berberis fendleri* A. Gray and *B. canadensis* Mill.

Although three-fourths of the control area is now on maintenance, the remaining one-fourth comprises some of the most heavily infested and persistent barberry areas. It includes also some of the most difficult terrain in the 18 States. Under such conditions field operations are slower, and considerable rework will be required to bring these areas to a maintenance status. At the end of 1946 rework was behind schedule on areas totaling 48,135 square miles. In some of these areas barberry regrowth is now producing fruit and beginning to reseed the territory.

REWORKING OF AREAS ON SCHEDULE ESSENTIAL TO ERADICATE BARBERRY

Some idea of the extent to which rework of known infested areas is behind schedule can be seen from the results of the 1946 work. Of the

8,363 properties reworked, 1,754 were reinfested, and bushes producing seed were found on 1,035. If it had been possible to do the rework on schedule—that is, at intervals of 5 to 7 years—so as to preclude seed production, many of these properties could have been placed on maintenance much sooner. Barberry seed may remain viable in the soil for 10 to 12 years, which is an important consideration in planning rework and maintenance programs.

The danger involved in letting new barberry bushes become established after the initial working is exemplified by the damage to grain from rust on farms in York and Adams Counties, Pa., during 1946, as shown in figure 4. Barberry bushes became reestablished near Davids-

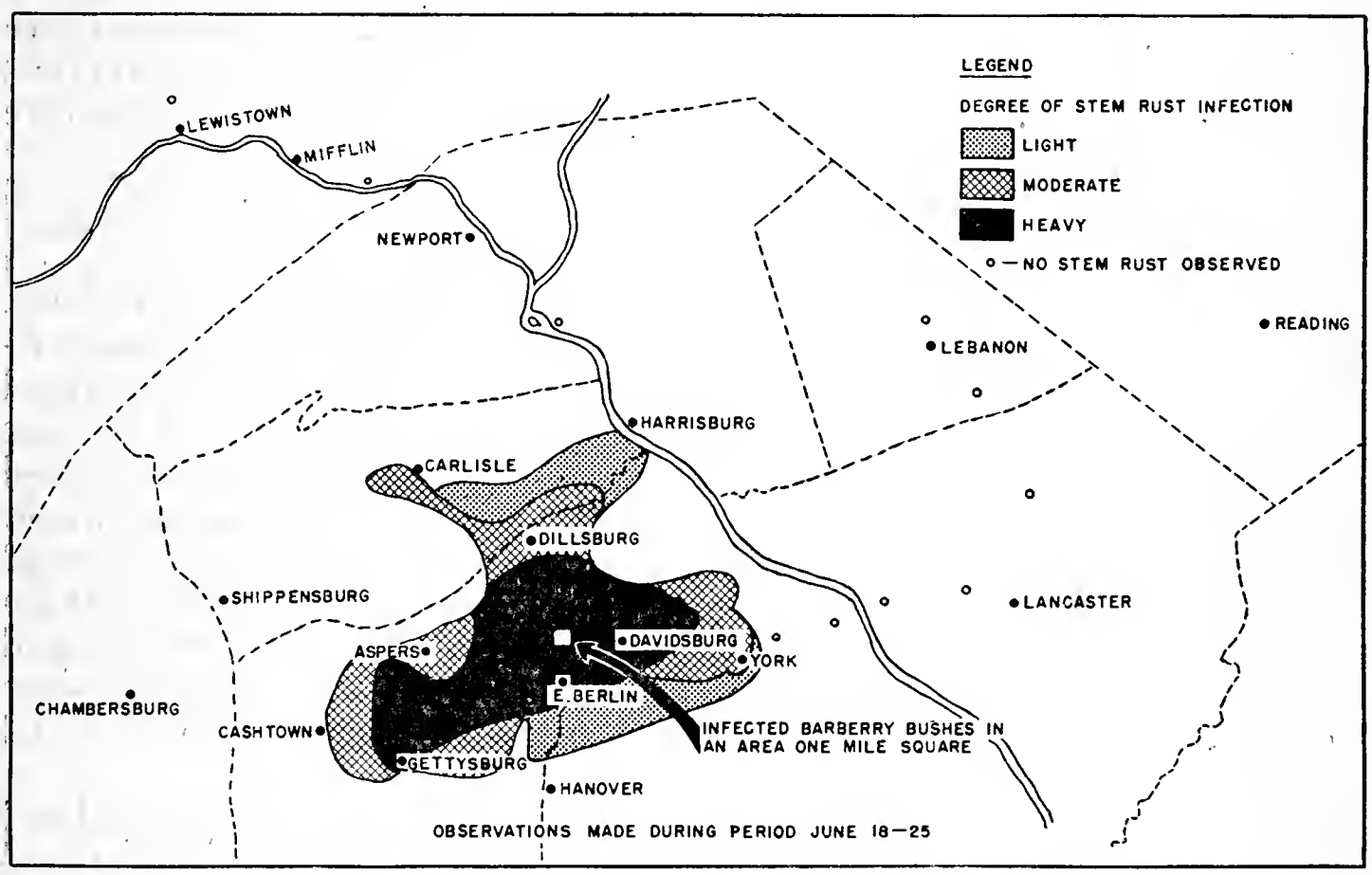

FIGURE 4.—Spread of stem rust from barberry bushes to wheat in Adams and York Counties, Pa.

burg. Stem rust developed early on these bushes and attacked nearby grain. By harvesttime the rust had spread over 500 to 600 square miles of surrounding territory. Losses ranged from 10 to 60 percent of the crop in individual fields, with an aggregate loss for the area estimated at $300,000. This loss would not have occurred if rework aimed at keeping barberries suppressed on such areas could have been carried out on schedule.

PREVALENCE AND SPREAD OF STEM RUST

Wheat losses from stem rust during 1946 were light or negligible in most States. In Pennsylvania, Virginia, and West Virginia, however, the disease developed abundantly in barberry-infested areas, and State-wide losses ranged from about 3.5 to 5 percent. Oat losses were 4 percent in Texas, 2 percent in Virginia, and less than 1 percent elsewhere. Losses in barley and rye were negligible.

Surveys to determine the number and prevalence of physiologic races of wheat stem rust resulted in the identification of 24 races and biotypes from 747 collections. However, only 3 races were widespread

and prevalent—namely, 56, 38, and 17—which together comprised 90 percent of all identified isolations from collections of stem rust of wheat. The importance of barberry in the production and perpetuation of stem rust races was again demonstrated in 1946, when 16 races were obtained from 47 collections in eastern Washington and 12 races were obtained from 51 collections in Virginia.

Five races of oat stem rust were obtained from 486 collections. They include races 2, 5, 7, 8, and 10. Races 8 and 10 comprised 52 percent of all isolates. They have increased from the obscure position of 1.5 percent of the isolates in 1939 to the predominating races in 1946. These races attack Vicland, Boone, Tama, and other varieties of oats that derive their stem rust resistance from Richland. Race 7, which was found in 1945 near barberries in New York, reappeared there again in 1946. This race attacks some of the newer resistant oat varieties, such as Clinton, Benton, Bonda, and Mindo, which owe their stem rust resistance to White Tartar.

RUST-SUSCEPTIBLE BARBERRY EXCLUDED FROM STATES PROTECTED BY QUARANTINES

An important phase of the barberry-eradication work is to prevent the reintroduction of rust-susceptible plants into the States participating in the control program. All nurseries in these States are examined annually by State inspectors. Nurseries, both within and outside the protected States, that request permits to ship barberries regulated by quarantine are inspected as part of the barberry eradication work. Permits under provision of Federal Quarantine 38 were granted 43 nuseries, of which 29 were within the quarantine area. Most of them were found to be free of susceptible barberry, but a few species and varieties that had never been tested for susceptibility to stem rust were encountered, and the shipment of such stock has been prohibited until such tests can be completed.

Wherever possible, nurseries were inspected jointly by both Federal and State officials. This type of cooperation provided a good opportunity to explain the provisions of the State and Federal quarantines. As a result 18 nurserymen and seed dealers outside the protected States agreed to destroy all their susceptible stock and grow only approved immune or highly resistant barberries.

Of 82 species, varieties, and hybrids of barberry tested during the year, 52 were definitely susceptible to stem rust; 7, including 2 so-called thornless varieties of *Berberis thunbergii*, have been classed as immune, and the remainder will be given further tests.

NEW HERBICIDES TESTED ON BARBERRY

The search for a more effective and economical herbicide for use on native barberries in Virginia, West Virginia, and Colorado was continued during 1946, and several of the newer herbicides were tested on common barberry (*Berberis vulgaris*). Numerous formulations of 2,4-dichlorophenoxyacetic acid (2,4-D) and various concentrations of sodium chlorate and ammonium sulfamate were tested on native barberry (*B. canadensis*) in Virginia and West Virginia, and on *B. fendleri* in Colorado. Preliminary observations in the fall of 1946 indicated that ammonium sulfamate was effective on *B. canadensis*, but less so on *B. fendleri*. The small amount of this chemical necessary for a complete kill increases its possibilities for practical use in de-

stroying barberry bushes. Some of the 2,4-D formulations had sufficient herbicidal value to warrant further tests. Chlorates were effective against native barberry bushes, but because of the fire hazard and the labor required in applying the chemical an effort is being made to find a more satisfactory herbicide.

CONTROL OF WHITE PINE BLISTER RUST

The accelerated cutting of mature white pine for war uses added large acreages of cut-over lands to the area threatened with blister rust. On many of these lands white pine and ribes have regenerated, and prompt removal of the ribes is necessary to save enough of the young trees to produce the next timber crop. Control activities have not kept up with the rapid accumulation of these cut-over lands, or with the rework which is long overdue on large acreages partially protected by initial removal of the ribes prior to the war. Shortages in qualified labor, time lost by use of blister rust crews for fire-fighting emergencies, the 5-day week, increases in salaries and wages, and higher prices for supplies and equipment have combined to increase the cost of ribes removal and reduce the acreage covered.

Federal, State, and local agencies increased their contributions for cooperative removal of ribes for the current year, and an expanded program was begun to make up the ground lost during the war years, when only a holding program was practicable. State and local agencies provided $492,293 for this work, an increase of $127,626. This expanded program made possible substantial increases in accomplishment over the previous year, by working 872,927 more acres, even though the funds did not become available until the middle of the field season. The results of this work for the calendar year 1946 are shown in table 2.

TABLE 2.—*Ribes removal work of all cooperating Federal, State, and private agencies for the calendar year 1946*

Region	Initial eradication	Reeradication	Total	Effective labor	Ribes plants destroyed
	Acres	*Acres*	*Acres*	*Man-days*	*Number*
Northeastern	221, 859	640, 624	862, 483	64, 922	4, 989, 209
Southern Appalachian	281, 992	301, 806	[1] 583, 798	[1] 19, 240	1, 196, 492
North Central	112, 246	187, 610	299, 856	39, 989	4, 890, 501
Northwestern	10, 605	45, 767	56, 372	64, 490	4, 608, 777
Pacific Coast	36, 680	52, 620	89, 300	75, 571	9, 465, 528
Total	663, 382	1, 228, 427	1, 891, 809	264, 212	25, 150, 507

[1] Includes 548,616 acres found ribes-free and 7,132 man-days blocking out ribes-free areas.

Required rework continued to receive first consideration and comprised about two-thirds of the program. The cooperating agencies employed 7,170 persons and operated 106 camps for workers in forest areas remote from centers of population. Blister rust control was

maintained around 17 nurseries containing over 38,000,000 white pines by removal of 6,021 ribes bushes from 7,777 acres of protective zones. The loss of 144,551 infected white pines, mostly in plantations, was prevented by removal of the diseased portions of these trees.

2,4-D AND OTHER NEW CHEMICALS IMPROVE ERADICATION METHODS

Ammonium sulfamate and 2,4-D replaced sodium chlorate and calcium chloride in the treatment of stream-type ribes in the western white pine region. Ammonium sulfamate is effective on both *Ribes petiolare* and *R. lacustre*, which often occur together. Its use in such situations simplifies their eradication, since previously *R. petiolare* was killed with calcium chloride and *R. lacustre* had to be pulled by hand. In the sugar pine region large-scale field tests showed that concentrations of *Ribes roezli* can be killed more effectively, and at less cost, with 2,4-D than by the regular hand-grubbing methods. This species comprises about nine-tenths of the ribes in sugar pine control areas and is the most troublesome species to suppress. About 328 acres bearing heavy populations of *R. roezli* were sprayed with 39,950 gallons of 2,4-D, and at the end of the season checks showed an apparent kill of 93 percent. It now appears that young bushes can be effectively treated with 2,4-D from the middle of May until the first of August. On old or fully matured bushes spray work should be terminated about a month earlier.

Tests indicated that the sodium, ammonium, and triethanolamine salts and the butyl ester of 2,4-D are equally effective on *Ribes roezli* when comparisons are made on the basis of their acid-equivalent content. Other species found highly susceptible to 2,4-D are *R. americanum* and *R. bracteosum*.

Further tests of ammonium sulfamate (80 percent) on *Ribes inerme* and *R. lacustre* and initial tests on *R. binominatum*, *R. erythrocarpum*, *R. lobbii*, and *R. tularense* show it to be an effective all-purpose herbicide for ribs. For species not susceptible to 2,4-D, ammonium sulfamate may be used as a crown treatment or as a combination crown drench and top spray. This chemical is bulkier, more expensive, and more corrosive to equipment than 2,4-D, and should be used only for work that is too difficult and costly for other methods.

Timber-management methods designed to reduce the regeneration of ribes and help suppress these rust-spreading plants are being applied by the Forest Service in the western white pine region. Their timber-making rules in the white pine type are being revised to incorporate these methods as standard practice.

BLISTER RUST CONTINUES TO SPREAD

Since its separate introduction into the Northeastern and the Northwestern States, blister rust has spread slowly but steadily, until it is now present in the principal commercial white-pine regions and extends over much of the area in which the white, or five-needled, pines occur. The extent of its spread in relation to the distribution of the white pine is shown in figure 5.

In 1946 infection was found on pine for the first time in Jo Daviess

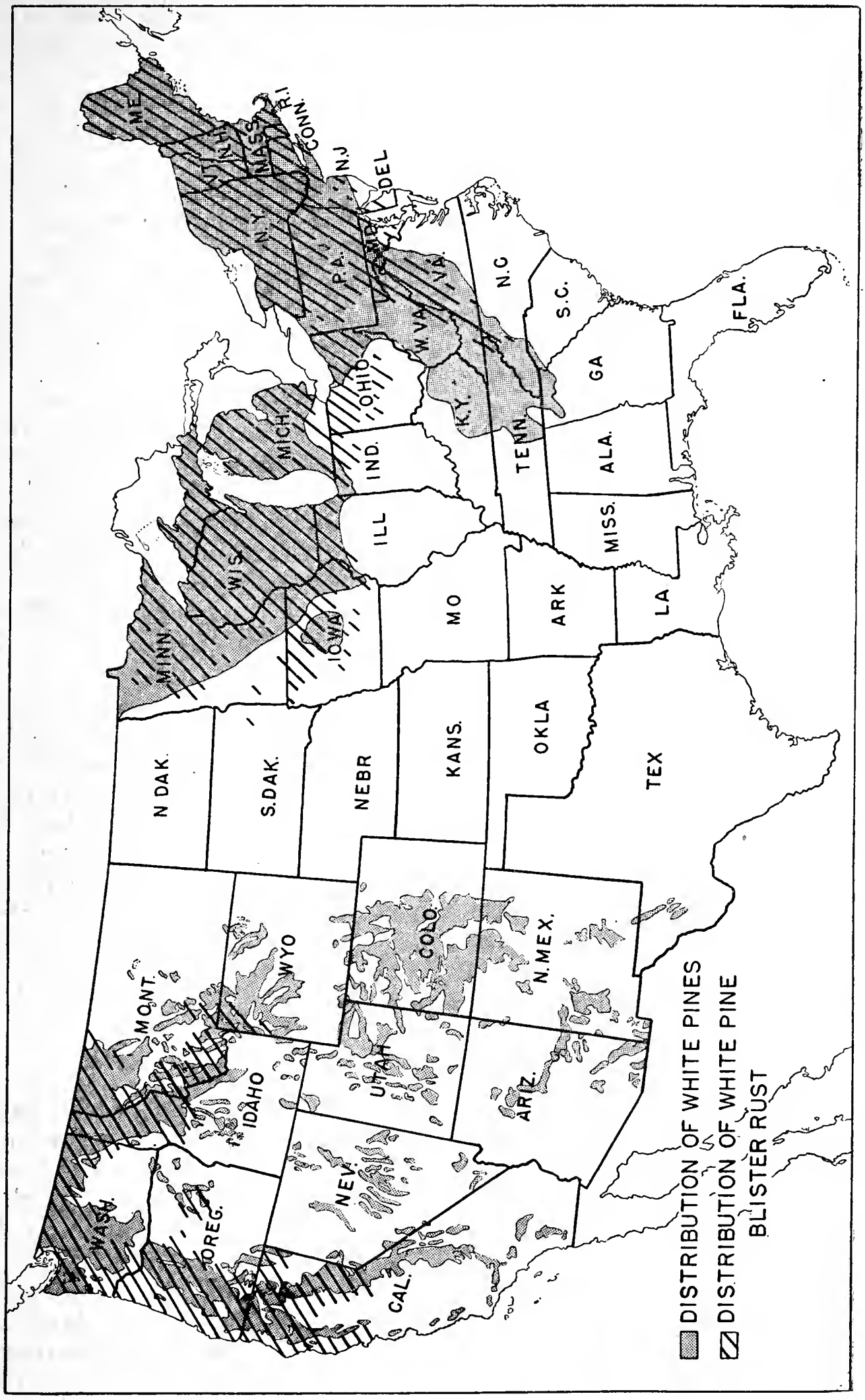

FIGURE 5.—Distribution of white pi

County, Ill., and on ribes in Sussex County, Del.; Talbot and Queen Annes Counties, Md.; Cook, Du Page, Lee, and Rock Island Counties, Ill.; Adams, Fulton, Huntingdon, Kosciusko, Marshall, Noble, and Whitley Counties, Ind.; Henry and Louisa Counties, Iowa; Pickaway, Stark, and Tuscarawas Counties, Ohio; and Teton County, Wyo. The last-mentioned discovery extends the known limits of the rust southward 110 miles from Mammoth Hot Springs in the northwestern part of Yellowstone National Park to Teton Pass, west of Jackson.

In the sugar pine area of Oregon and California there was no further advance of the disease on ribes, but pine infection was found for the first time on the Tahoe and Eldorado National Forests. The Eldorado infection represents a southward advance in the Sierra Nevadas of 39 miles to a point 204 miles south of the Oregon border. Additional pine infections were found in the general zone from which the rust had been previously reported.

In a few localities, especially in the Klamath section of northwestern California, and in northeastern Minnesota and northern Idaho, pine stands are being severely damaged. In Idaho the white pine on 168,000 acres of forest area has been lost to blister rust, and this acreage therefore eliminated from the control area. In the Northeastern States areas of infected pines have been located at Caratunk and Camden, Maine; Whitefield, New Durham, and Campton, N. H.; Orwell, Vt.; and Hannawa Falls and Ellenville, N. Y. Severe loss in some of these areas is due to infections originating several years ago prior to the removal of ribes.

Blister rust infection of white pine occurs annually in varying amounts. The smaller trees are killed in a few years, and the older ones after many years. Damage is severe in unprotected areas where ribes are numerous, while in those fully protected, further infection and damage have practically ceased. Between these extremes there is, as a result of the initial removal of ribes, a large acreage under partial control on which varying degrees of ribes regrowth has taken place. Infection of pines on this acreage varies with the abundance of ribes regrowth and the length of time since the original bushes were destroyed. Removal of the ribes by reworking is necessary to correct this situation and prevent further pine losses.

PROGRESS OF CONTROL RAPID IN SOUTHERN APPALACHIAN REGION

Surveys in the southern Appalachian region show that much of the white pine area is free of ribes plants. After careful survey for pine and ribes, such areas are indicated on maps and recorded as on maintenance. Thus, progress in control has been more rapid than in other white pine regions where ribes are more generally and abundantly distributed.

The ribes-free acreage, the 91 percent initially worked and on maintenance, will need no further attention for several years. Most of the ribes-bearing areas, or about 6 percent of the total control acreage, needs reworking one or more times at intervals of about 5 years until all danger of sprouts and regrowth from seeds remaining in the soil has passed. Only about 3 percent of the control acreage requires initial work.

QUARANTINE AND REGULATORY ACTIVITIES

JAPANESE BEETLE QUARANTINE ENFORCEMENT

ADDITIONS TO REGULATED AREA

Sections of Monroe and Summers Counties, W. Va., were placed under quarantine because of the extent and intensity of the Japanese beetle infestation found at Alderson. In New York, Waterloo in Seneca County was added to the regulated area because it was considered impractical to apply control measures there.

FARM PRODUCE AND CUT FLOWERS

In view of the importance of fresh vegetables, fruits, and flowers reaching markets with the least possible delay but free of Japanese beetles, recently developed methods of treating such products prior to certification have been approved. The application of DDT dusts to the empty and then loaded refrigerator cars and trucks carrying white potatoes to make and keep them free of living Japanese beetles was authorized on May 17, 1947. This method not only permits immediate movement of the produce, but costs less than fumigation with methyl bromide.

In cooperation with State and other Federal agencies, tests were started to develop a "one-shot" method of applying DDT alone and in combination with other insecticides to destroy adult beetles in vehicles. Such a treatment, applied to restricted articles in cars and trucks when they reach the periphery of the infested area, could reduce quarantine work and delays at congested producing and loading centers in the infested areas.

During the Japanese beetle flight periods 4,400 carloads of farm produce and 15,600 packages of cut flowers were certified for shipment from the heavily infested area to the nonregulated area.

CERTIFICATION OF NURSERY AND GREENHOUSE STOCK

Plant-quarantine inspectors, operating from 34 stations in the regulated areas, made 20,300 calls at places of business and homes in the fiscal year. About 51,600,000 plants were certified for shipment to destinations in the nonregulated area and Canada. In addition, approximately 23,400,000 plants were moved between dealers within the regulated areas. They were inspected or otherwise made eligible for certification for later interstate shipment under quarantine regulations. All the 75,000,000 plants were certified as being obtained from uninfested premises, inspected and found devoid of infestation, or treated in a manner to kill any existing infestation.

Surveys in and around nurseries and greenhouses in the regulated areas showed about 400 noninfested. Plants from these establishments are qualified for certification without examination as long as they maintain a noninfested status. To prevent the introduction of beetles into noninfested areas, certification of plants and potting soil was required for movement to such establishments from other growers located within the regulated area.

DDT was found to kill grubs of the Japanese beetle in more types of soil than 20 times as much lead arsenate. Growers report injury to only a few of 750 plant species and varieties grown in DDT-treated

soil. DDT was applied to the surface of 70 acres of soil in nursery plots and frames and to 560 cubic yards of potting soil during the year.

The quantities of plants and soil treated with chemicals in lieu of visual inspection, as a basis for certification have increased from year to year. The approximate numbers of plants treated during the year by different methods were as follows:

Ethylene dichloride as dip for lifted plants	932,000
Ethylene dibromide-ethylene dichloride mixture poured onto soil around plants	296,000
Methyl bromide as fumigant for lifted plants	1,463,000
Methyl bromide solution poured onto soil around plants	1,700

In addition, more than 443,000 plants growing in soil treated with DDT or lead arsenate were certified. According to growers' reports, most kinds of nursery and greenhouse plants are not significantly affected by ethylene dichloride or by the dibromide-dichloride mixture.

About 2,800 cubic yards of soil was treated. Approximately seventy percent of this volume was fumigated with carbon disulfide, but other methods included methyl bromide, naphthalene, and chloropicrin fumigation, steam and heat treatments, and applications of DDT mixed with soil.

HIGHWAY AND TRANSIT INSPECTION

Two inspection platforms were opened in Virginia on June 17, one at Norfolk and the other at Stratford, for the inspection of uncertified produce from other points in the regulated area. At these points also trucks destined to points outside the area were inspected and if necessary cleaned of litter in which Japanese beetles might be concealed. Trucks believed to be carrying Japanese beetles or restricted articles to points outside of regulated areas were inspected at eight other road stations in Virginia. Two road-patrol crews made similar inspections in Ohio in 1946. The highway inspection service was a deterrent to would-be violators, and provided opportunities for growers and independent truckers to learn about the Japanese beetle quarantine requirements. Sixteen truckers out of nearly 100,000 refused to stop for inspection, or otherwise to abide by quarantine regulations at the inspection stations operated in Virginia. Six of the trucks were later located, but no formal charges were made against the owners.

A potato shipper in New Jersey was fined $150 for three uncertified truck shipments to western Ohio in August. The trucker who transported one of these loads was also convicted in the United States District Court and fined $50.

Transit inspectors found 393 packages, largely sent by express and mail, without proper certification. All the cases were investigated and settled out of court.

GYPSY AND BROWN-TAIL MOTH INSPECTION AND CERTIFICATION

CERTIFICATION OF REGULATED PRODUCTS

State agencies cooperated in the enforcement of the gypsy moth and brown-tail moth quarantines. In addition to the regularly assigned personnel, the States increased their support by furnishing trained inspectors and by paying a part of the salaries of regular Federal inspectors during the spring months.

Selected employees of the New York State Department of Conservation and of this Bureau were authorized to issue certificates for the noncommercial movement of articles from the regulated area.

Increased attention was given to the certification of restricted articles that originate at noninfested sites within the regulated area. At the end of the year 332 commercial establishments that were found to be free of infestation were permitted to ship under permits on a year-round basis. These establishments made 129,178 shipments of forest, stone and quarry, and nursery products during the year. Inspections were made of 355 sites where logs, pulpwood, and evergreen boughs were being cut on a job basis. From those sites found to be free of infestation certificates were issued for the specific operation.

Cooperative tests were made with DDT to develop more efficient and economical means for certification of various products in lieu of actual inspection or fumigation. Such tests were made at 5 quarries, 20 junk yards, 18 lumber-drying sites, 1 nursery, 1 loading and shipping point, and 3 unclassified locations. In some instances the DDT was applied to both the products and environs, and in others to the environs or to the products only. These tests were carried out in cooperation with producers and processors.

Limited permits for the movement of noncertified restricted articles were authorized when the articles would be handled and processed at the point of destination in a manner that would destroy any transported forms of gypsy or brown-tail moths. During the year one pulpwood user in the suppressive zone received under limited permit 23,496 cords of pulpwood from the generally infested area. Other operators received 2,080 cords of pulpwood, 2,510 bales of excelsior waste, and 650 bags of sawdust.

During the war years large volumes of lumber moved directly from the saw pits, and hence could be certified as noninfested because of the manner and season of its production. Early in 1947 there was a strong trend against green lumber, and much lumber was placed in the drying fields, where it became subject to infestation during the moths' egg-laying period. This change caused a great increase in the amount of lumber requiring piece-by-piece inspection.

Methyl bromide fumigation of rough lumber and forest products increased. Materials such as excelsior waste and sawdust, which cannot be visually inspected, and fuel wood and edgings, which cannot be inspected economically, usually were qualified for certification by fumigation. During the year shippers fumigated more than 637,000 board-feet of lumber, 900 bales of excelsior waste, nearly 600 cords of fuel wood, and over 1,000 posts.

Total amounts of the more important restricted forest products that were inspected or treated and then certified for movement to the suppressive and nonregulated areas are as follows:

Lumber	board-feet	242,391,047
Logs, posts, poles	pieces	1,224,844
Pulpwood and fuel wood	cords	107,326
Barrel parts and crates	bundles	86,023
Excelsior, shavings, sawdust	bales	122,465
Wooden cable reels	pieces	17,038
Miscellaneous products	pieces, bags, bales	890,090

An increase in the number of small shipments of nursery stock resulting from some shift from wholesale to retail trade increased the amount of certification work. The unusually favorable fall weather and the late, cool spring caused a high peak in the inspection work in March and April. During the year inspections were made and certificates for movement were issued for more than 9,000,000 deciduous and coniferous trees and shrubs, and for 1934 boxes of plant cuttings and miscellaneous stock.

This was the first full year during which Christmas trees might be shipped from the area of heavy gypsy moth infestation without any special restrictions. Some cutters in the old heavily infested area found new market outside the area, and some cutters moved into the area to find more productive cutting sites. This shifting has not been completed. Five Bureau-owned fumigators were operated by State officials, and several cutters and shippers supplied and operated fumigators for loaded boxcars and closed trucks. Others constructed and operated six fumigation chambers for lots or truck-loads of Christmas trees and evergreen materials. About 472,000 Christmas trees and 100,000 bundles of balsam, laurel, and similar products were certified on the basis of approved fumigation under Federal supervision or after visual inspection.

A shortage of experienced workers and some strikes reduced the volume of business in New England stone quarries. The utilization of materials that were quarried years ago and left exposed to possible infestation caused an increase in inspection work. The more important products were certified in the volumes indicated: 4,669 tons of stone; 8,511 tons of granite; 43,186 tons of feldspar; 12,453 feet of curbstone; and 207,162 pieces of various types of quarry products.

Inasmuch as vehicles and other articles not specified in Quarantine 45 are subject to regulation only when found to be infested with gypsy moths or brown-tail moths, it is important that the chances of infestation of such articles be kept at a minimum and that the inspectors have knowledge of any existing infestation on articles which may be moved from the regulated area. For these reasons inspections were made at 234 tourist camps and trailer parks, 87 of which were found to be infested. The owners and occupants cooperated fully by destroying these infestations. Town gypsy moth wardens were encouraged to include such sites in their spraying areas.

As a part of reconversion and veteran-housing activities, many portable and knocked-down houses were moved from military bases and war-production sites in the infested area. Special efforts were made for inspection of these at the times requested so as not to interfere with the reconversion and housing programs.

Inspections were made at 255 junk yards, and egg clusters were found at 21 of the establishments that ship, directly or indirectly through other dealers, to the nonregulated area. The owners took prompt measures to destroy existing infestations and in some cases to reduce chances of subsequent infestation.

Visits were made to all distributors of bottled gas and to 22 gas-cylinder establishments in the regulated area to see that they were complying with their agreement to clean and, where necessary, repaint cylinders prior to shipment to the suppressive or nonregulated areas. All distributors were cooperative in helping prevent dissemination of the gypsy moth.

ROAD PATROLS AT MARGINS OF REGULATED AREA

Two road patrols operated most of the year on highways in the marginal section of the area generally infested with gypsy moth. Additional crews were placed on the highways during the peak movement of Christmas trees. These crews intercepted 172 trucks and cars carrying regulated articles that had not been certified. A few of the potential violators had their loads certified on location, but most of them returned their loads to established inspection stations in the regulated area.

VIOLATIONS OF GYPSY AND BROWN-TAIL MOTH QUARANTINE

Transit inspectors of the Bureau intercepted 383 shipments containing regulated articles that were not certified. Bureau inspectors and road patrols also observed irregularities on the part of 65 individuals. Of the total violations, 444 were cleared up without court action, State courts found 2 persons guilty of interstate quarantine violations and fined them a total of $55, and 2 charges remained unsettled at the end of the year.

DUTCH ELM DISEASE DOMESTIC QUARANTINE REVOKED

The Federal quarantine to retard the interstate spread of the Dutch elm disease was revoked on May 1, 1947. This action was taken because control of the movement of elm material had not provided practical means of preventing spread of the disease. It was considered that commodities which may contribute to long-distance spread can be safeguarded with equal effectiveness through action by individual States. The bark beetles that spread the disease move considerable distances by natural means. Quarantine action cannot prevent this spread through flight of these insects.

The quarantine prohibiting the importation from Europe of articles that may carry the Dutch elm disease fungus remains in force.

LIGHT INFESTATION PERMITS FEWER RESTRICTIONS UNDER MEXICAN FRUITFLY QUARANTINE

The amount of citrus fruit produced in the Texas area under regulation for the Mexican fruitfly exceeded that produced in any of the preceding 4 years. Quantities sterilized, however, were below the previous season's total, because delayed larval infestations permitted a longer shipping season without sterilization. Larval infestations were almost a month late in developing owing to abnormally cool weather, February temperatures in this area being the coldest in 42 years. About 6,300 traps were operated in surveying 320 properties. Trapping was discontinued the last week in March, after larvae had been found on 51 properties. Beginning April 7 permits were required to harvest grapefruit. A rapid increase in larval infestations was observed by grove inspectors during the latter half of April. Not until April 28, however, was sterilization required for all grapefruit harvested for shipment. The 1946–47 harvesting season for commercial shipments extended from September 1 through June 30.

Trapping operations and market inspections were continued in Matamoras, Mexico, to detect the northward flights of the fruitflies which annually infest the Texas citrus plantings.

Two highway inspection stations continued in operation at Fal-

furrias and Riviera, Tex. Many small lots of fruit being moved in passenger cars were confiscated.

Sterilization was conducted in 30 packing plants. No oranges were treated during the year, although 160,675 boxes of oranges are included in the quantity of fruit reported as processed as juice or fruit sections. The unprocessed portion of the crop was shipped as fresh fruit, considerable quantities going to both England and Sweden.

Comparative data on quarantines of fruit produced, sterilized, and processed and the number of fruitfly infestations found in the regulated area during the last four seasons are given in table 3.

TABLE 3.—*Citrus fruit produced, sterilized, and processed, and infestations of Mexican fruitfly larvae in the regulated area of Texas, 1944–46*

Fiscal year	Fruit produced	Fruit sterilized	Fruit processed	Infestations
	Boxes	*Boxes*	*Boxes*	*Number*
1944	21, 299, 760	1, 559, 957	8, 332, 920	576
1945	26, 454, 600	1, 698, 525	9, 638, 388	225
1946	28, 218, 816	2, 977, 000	9, 644, 128	310
1947	31, 697, 475	2, 141, 892	8, 653, 800	159

PINK BOLLWORM QUARANTINE ACTIVITIES

REGULATORY CHANGES

Administrative instructions effective October 28, 1946, modified requirements of certification of cottonseed for movement to points outside the heavily infested area by authorizing an alternate method of treatment involving fumigation with methyl bromide.

RESULTS OF INSPECTION FOR PINK BOLLWORM

New infestations in two Texas counties, Hockley and Wharton, represented the only spread of the pink bollworm during 1946. Infestation was extremely light. Hockley County, in northwestern Texas, was placed under regulation after the pink bollworm was found there in 1933, and was released in 1944 after several years' negative findings. Wharton County, heretofore free from infestation, adjoins Matagorda and Jackson Counties, both of which have been infested for several years. Inspections in all other counties adjoining the regulated areas were negative. Negative results were likewise obtained in cotton-growing areas in Florida, South Carolina, Georgia, Alabama, Mississippi, Louisiana, Oklahoma, and California, and in nonregulated cotton-growing parts of Texas outside of Hockley and Wharton Counties.

Inspection was carried on with negative results in southwestern Louisiana and the Trinity Bay area of Texas. In both places this was the most comprehensive inspection possible in an area and for the third consecutive year negative results have been obtained in the regulated part of Louisiana. It is therefore believed that the aggressive measures taken following the 1943 outbreak of the pink bollworm have been successful in eradicating infestation, and the area is being released from quarantine.

In the regulated area of south Texas there was a reduction in infestation for the second year in the heavily infested counties of Hidalgo, Cameron, and Willacy in the lower Rio Grande Valley. The counties at the northern extremity of the lightly infested area were free of infestation. A build-up of infestation, not entirely unexpected in view of unfavorable weather for cultural controls during the fall for two or three successive years, was discovered in localized areas of Refugio, Calhoun, Matagorda, Maverick, Duval, and Jim Wells Counties. These are the only counties in which there was significant increase in infestation in the 1946 crop over that of 1945. From 500 to 1,500 acres in each county are involved.

In northwestern Texas infestation continued to be very light. Several counties in the eastern part of the area were apparently free of infestation, encouraging the belief that perhaps spread in this section has been blocked. There was no material change in the regulated areas in New Mexico and the irrigated valleys of western Texas. Much of the Arizona area was apparently free of infestation, although a small isolated area in Maricopa County showed considerable increase.

For the 1946 crop season, 38,872 bushels of gin trash were inspected in regulated areas, as follows: Arizona, 15,599; Louisiana, 248; New Mexico, 1,147; and Texas, 21,879. A total of 26,699 pink bollworms were found, 430 in Arizona, none in Louisiana, 322 in New Mexico, and 25,947 in Texas. In the field 7,549,991 bolls, blooms, and squares were inspected in Arizona, Louisiana, and Texas, and 1,796 pink bollworms were found, all in Arizona and Texas.

Inspection of 32,476 bushels of gin trash from States outside the regulated areas—Alabama, California, Florida, Georgia, Louisiana, Mississippi, Oklahoma, South Carolina, and Texas—yielded only 2 pink bollworms, both from Texas. A total of 55,481 bolls, blooms, and squares were inspected in fields of Alabama, Florida (cultivated cotton), Louisiana, Mississippi, Oklahoma, and Texas, with negative results.

Infestation in wild cotton in Florida continues to be kept low, and there has been no spread of the pink bollworm from such cotton to the cultivated cotton areas since 1934. Since discovery of the pink bollworm in the wild cotton plants growing in the jungles and waste areas in southern Florida, the infestation there has been reduced from a high of 40 percent in some sections to an average of less than one-tenth of 1 percent. Since the probability of spread from wild cotton to domestic plantings in the Southeastern States by natural means is in direct ratio to the density of the infestation, it is believed that this part of the program continues to be of considerable value to the entire pink bollworm program. The number of wild cotton plants removed varies annually, but the general trend is downward. Since the project was started 16,981,479 plants have been removed, 150,269 during the last year. There was an increase in number of fruiting plants removed during the 1946 season, but a decrease in the total number of all classes of plants removed.

CLEAN-UP ACTIVITIES CONTINUED

The highly effective control program in the heavily infested lower Rio Grande Valley of Texas, first put into practice in 1945, was continued in connection with the 1946 crop. This program involved the enforcement of a much earlier deadline date—August 31—for cotton-

stalk destruction after completion of the harvest than had ever before been in effect. Excellent results have been obtained from this program, which is designed to eliminate at least one generation of pink bollworm and reduce the number of larvae going into hibernation. Any larvae thereby forced into hibernation so early have to remain there longer, with consequent higher mortality and fewer bollworms to emerge to infest the next crop. Although an early and effective clean-up was secured in 1946 by the established date for stalk destruction, unfavorable weather in September and October prevented complete maintenance of a host-free period. There was also some fruiting of volunteer cotton, which may have resulted in the production of a few overwintering larvae.

The lightly infested area in south Texas also must have intensive cultivation in order to control the pink bollworm. Such practices require early destruction of cotton plants after harvest and the subsequent maintenance of a host-free condition. Unfavorable weather in 1946 during the time scheduled for stalk destruction prevented farmers for the second or third consecutive year from complying with the prescribed deadlines, with resulting failure to establish a host-free period on schedule in a number of sections.

In 1945 and 1946 DDT was used to check infestations which developed in fields early in the season in the lower Rio Grande Valley of Texas. In 1946 under a cooperative arrangement with the Mexican Government the program was broadened to include a few fields near Matamoros, Mexico. Although it is difficult to evaluate fully the benefits, since all fields showing potentially heavy infestation were treated, those treated developed very little infestation.

A program has been inaugurated on a cooperative basis with the States concerned to use DDT dust to reduce infestation in those areas where significant increase was found. This includes two restricted areas of Maricopa County, Ariz., and several places where infestation has built up in south Texas outside the lower Rio Grande Valley.

A total of 930,518 bales of cotton were ginned at 583 gins under dealer-carrier permit in Texas, New Mexico, Arizona, and Louisiana; 400,815 tons of seed were given the heat treatment; 365,687 tons of seed were processed at the 49 designated oil mills and 1 heat-treating plant; and 24 compression plants compressed 1,046,770 bales of lint and 5,275 bales of linters. A total of 11,078 bales of lint and 15,061 bales of linters from Mexico were vacuum fumigated. At the two road stations maintained to inspect highway traffic from the quarantined area in the lower Rio Grande Valley, 302,813 cars and trucks were inspected, and 2,738 found to be carrying contraband material were intercepted.

Subsequent to the finding of the pink bollworm in Wharton County, ginners were contacted relative to installation of cottonseed-heating equipment. Since these installations could not be made in time for heating of seed from the 1946 crop, the Bureau and the State Department of Agriculture cooperated in a program whereby all seed was treated.

ACHIEVEMENTS IN COOPERATIVE CONTROL WORK IN MEXICO

Cooperative work with Mexico has continued to be very worth while. All phases of regulatory and control practices resulting from such cooperative work continued to approach methods and results being

achieved in the United States. One outstanding achievement during the year was the adoption of fixed planting and stalk-destruction dates in the Matamoros, Tampicos, area to conform with dates applicable to the adjacent area in the lower Rio Grande Valley of Texas. Stalk destruction in La Laguna was completed approximately 1 month earlier than in previous years. Regulatory treatments showed considerable improvement during the year, particularly in the interior cotton-growing areas of Mexico. This is especially true in the handling of baled cotton lint to be expected to or through the United States from Torreon, Coahuila, Mexico.

WHITE-FRINGED BEETLE REGULATED AREA MODIFIED

State and Federal quarantines relating to the white-fringed beetle have been revised to include most of the newly found infested areas. Provisions have been made for treatment of plants and other commodities when necessary so they may be moved to noninfested areas without hazard of spreading the beetles.

INSPECTION AT TRANSFER POINTS

During the year transit inspectors were assigned to several special activities involving quarantine enforcement because of their specialized knowledge of transportation procedures.

In the summer of 1946 inspectors assisted in enforcement of the New York State golden nematode quarantine by supervising the cleaning of 81 cars used to transport potatoes purchased under the Production and Marketing Administration program and moved from the regulated area in Nassau County, Long Island, to distilleries at Schenley and Philadelphia, Pa. These activities were part of the program to prevent the spread of this serious potato pest.

Inspectors again assisted in the enforcement of the Japanese beetle quarantine by maintaining waybill and carlot inspection at classification yards at Columbus and Crestline, Ohio, through which pass the majority of westbound cars of fruits and vegetables from the heavily infested regulated areas. Over 126,000 waybills and 2,860 cars were examined, and 47 irregular movements were reported.

During the winter transit inspectors at southern points were appointed as collaborators by several Southern States. They were furnished with State credentials authorizing them to assist in the enforcement of State sweetpotato weevil quarantine, intended to prevent the movement into such States of sweetpotatoes from the heavily infested area of central Louisiana. Seventy-five apparent violations of State sweetpotato weevil quarantines were reported.

Regular transit-inspection activities were conducted at 7 permanent and 10 seasonal terminals by 11 permanent inspectors, 19 part-time or seasonal inspectors, and 10 part-time State collaborators. Through May 31, nearly 1,600,000 shipments were inspected, and 1,561, with destinations in all States, the District of Columbia, and Canada, were reported as apparent violations of Federal domestic plant quarantines. In addition 616 shipments were found to be moving in apparent violation of State or District of Columbia nursery inspection or quarantine requirements. These interceptions were reported to State or district officials.

FOREIGN PLANT QUARANTINE ACTIVITIES

SHIP INSPECTION AT PORT OF ENTRY

The total number of ships arriving decreased by 15 percent from the 1946 total to 40,113, but the number bearing prohibited plant material rose from 18 percent in 1946 to 22 percent in 1947. The decrease in arrivals was due in part to diminishing shipping directly associated with the war effort and was most pronounced on the west coast. Arrivals on the Gulf coast increased over 1946. The total arrivals, despite the decrease, were 29 percent greater than in 1941, the last prewar year. Moreover, the increasing volume of civilian passenger traffic and large increases in cargoes subject to plant-quarantine restrictions increased, rather than diminished, the demand for quarantine protection. Maritime port inspection continues to be of major importance in plant quarantine.

The record of ship inspection appears in table 4. No data are given for ships engaged only in Great Lakes trade.

TABLE 4.—*Number of ships arriving, inspected, and bearing prohibited plant material, fiscal year 1947*

Origin	Arriving	Inspected	Bearing prohibited material
Foreign ports, direct	27, 689	27, 330	6, 896
Foreign ports, via United States ports	8, 333	7, 123	1, 164
Foreign ports, via Hawaii	273	273	171
Foreign ports, via Puerto Rico	43	43	15
Hawaii, direct to mainland ports	899	899	345
Hawaii, via United States mainland ports	190	190	25
Mainland ports, direct to Hawaii	794	794	57
Puerto Rico, direct	278	276	101
Puerto Rico, via United States mainland ports	141	141	6
United States ports, via Panama Canal	1, 473	1, 461	38
Total	40, 113	38, 530	8, 818

INSPECTION OF IMPORTED PLANT MATERIALS

There were substantial increases during the year in the importations of most restricted plant materials, especially fruit and vegetables and plant-propagating materials. The totals are shown in table 5.

TABLE 5.—*Summary of importations of restricted plant materials, fiscal year 1947*

Material	Containers	Pounds	Units	Additional quantities
Fruits and vegetables	15, 171, 459	5, 050, 434	232, 835	63, 008, 302 bunches.
Nursery stock and seeds	124, 657	58, 402	230, 896, 431	
Cotton lint, bagging, and products	2, 684, 002	103, 440, 535		1, 079, 484 bales.
Fibers and cereals	136, 609	713, 256	16	727, 804 bushels. 4,993 dozen.

In addition, through the cooperation of customs officers and the Canadian Department of Agriculture, a number of lots of restricted plant material were admitted at Canadian border ports, where no plant-quarantine inspectors are stationed.

Not included in the foregoing totals were several million importations of restricted plant material over the Mexican border in such small quantities that no entries are required by customs and no plant-quarantine record is made of them. Each of these small lots was inspected before release, and their handling required a large outlay of inspector-hours, particularly at the larger ports. Representatives of this Bureau also cooperated with the Bureau of Animal Industry and the Bureau of Customs in enforcing the foot-and-mouth disease quarantine at Mexican border stations.

Early in January it was discovered that broomcorn was arriving from Italy heavily infested with larvae of the durra stem borer, *Sesamia cretica* Led., an insect not known to occur in the United States.

TREATMENTS OF IMPORTED PLANT MATERIALS

The importation of restricted plant material is often conditional upon treatment, under the supervision of representatives of the Bureau, to insure the elimination of injurious plant pests. During the year the following materials were treated:

Cotton linters and bagging	bales	650, 857
Cottonseed cake and meal	pounds	14, 899, 028
	containers	51, 149
Cotton and linters	samples	22, 283
Liquor [1]	cases	7, 000
Fruits and vegetables	containers	5, 353
Plants, cuttings, bulbs, roots, etc	units	4, 710, 607
	containers	8, 810
Seeds	containers	13, 919
	pounds	1, 506
Broomcorn	bales	22, 283
Chestnuts, cipollini, and pigeonpeas	containers	51, 858
Miscellaneous plant products	lots	2, 698

[1] Because of weevil-infested vetch which contaminated the straw bottle-jackets.

Two thousand one hundred twenty-two lots of returned Army and Navy equipment were also cleaned or otherwise treated, largely on account of soil contamination.

AIRPLANE INSPECTION AT PORTS OF ENTRY

Prevention of plant-pest introduction through air commerce is now one of the outstandingly important problems of foreign plant quarantine. During the year 58,519 airplanes were inspected at 44 ports of entry. This total includes 4,666 arrivals from the mainland which were inspected in Hawaii by Federal personnel, and is substantially the same as the 1946 total despite the use of larger planes, the greater proportion of commercial flights, and the factors which tended at times to reduce air travel during the year. Prohibited plant material was found on 27 percent of the planes as compared with 21 percent in 1946—further evidence of the increasing importance of the problem. Aircraft now arrive regularly from as far away as Cairo, Egypt, with Chicago as the first port of entry in this country—another evidence of the potential threat of air traffic to the country by which the interior

as well as the seaboards could be jeopardized by foreign plant pests except for adequate foreign plant quarantine protection.

In all, 5,252 interceptions of insects and plant diseases were made from airplanes by Bureau representatives in 1947. Although many of these pests, including mosquitoes, were stowaways that might menace public health, pests of economic importance were found in plant material carried in baggage, cargo, mail, and stores. Among the insects found were a curculionid (*Brachyrhinus* sp.), a whitefly (*Aleurothrixus myrtacei* Bondar), an olethreutid (*Laspeyresia splendana* (Hbn.)), the pink bollworm, the Mediterranean fruitfly, the olive fruitfly, the Mexican fruitfly, the West Indian fruitfly and four other species of *Anastrepha—fraterculus* (Wied.), *serpentina* (Wied.), *striata* Schin., and *suspensa* (Loew)—and another tephritid (*Rhagoletis cerasi* (L.)). Among the 257 interceptions of plant diseases, 129 were on orchids, 61 were on miscellaneous flowers and other ornamentals, 3 on rice, 11 on citrus fruits, and 53 on miscellaneous food and fiber plants. Of particular interest was one interception of a rust fungus of cotton, *Cerotelium desmium* (Berk. and Br.) Arth., known in several other cotton-growing countries, but reported in this country only from a part of southern Florida.

During the year a laboratory was established at Beltsville, Md., for the study of this problem of "hitchhiking" insects. Solution of the problem will necessitate the development of aerosols and residual sprays that will kill all types of insects that may gain entry into the plane compartments, and of other treatment methods that will quickly eliminate insects that infest fruit, plants, etc., that are carried as cargo.

INSPECTION OF FOREIGN PARCEL POST

During the year there was a marked decrease in the volume of parcel post from members of the armed forces, whereas regular civilian foreign parcel post increased. Although the responsibility for protecting our agriculture against the entry of pests in mail from members of the armed forces rests almost entirely on the plant quarantine service, the improved conditions resulting from the decreasing volume of such mail permitted a shift of emphasis to more pressing demands for protection arising from other forms of commerce. The total number of packages examined in 1947 was 2,938,319, a decrease of 64 percent from 1946. Of this number 2,466 were refused entry, in whole or in part, because they contained prohibited plant material, as compared with the 2,882 similarly refused in 1946 out of the 8,161,717 packages examined that year. Packages diverted to another port for handling totaled 9,464, and 6,472 were released under permit. These figures all demonstrate the continued potential risk to American agriculture from unauthorized plant material arriving by mail from foreign countries.

INCREASE IN MEXICAN BORDER INSPECTIONS

The number of inspections of freight cars from Mexico totaled 68,675, an increase of more than 10 percent over 1946. This large volume, now approximately twice the prewar level, is characterized by many commodities requiring plant quarantine inspection whereas during wartime the movement consisted of metals and other strategic materials. The number of cars requiring fumigation was kept to a

minimum by the further employment of procedures and controls making it possible to waive fumigation where it could be done without risk of pest entry. The total number fumigated was 8,057, compared with 9,007 in 1946. The sale, at $4 each, of coupons valid for the fumigation of a freight car, amounted to $32,124.

In addition, 4,438 pullman cars and passenger coaches were inspected upon entry into this country, a small increase over 1946. Heavy tourist traffic from Mexico continued to account for a part of the increase from 5,789,244 other vehicles inspected in 1946 to 7,044,096 inspected in 1947. These examinations were made in cooperation with customs officers, as were the 1,581,452 pieces of baggage that were inspected during the year.

HAWAII AND PUERTO RICO STRATEGIC OUTPOSTS FOR PLANT QUARANTINE INSPECTION

In Hawaii the plant quarantine program is one of preventing foreign plant pests from being introduced into the Territory, or via Hawaii to the mainland and the plant pests of Hawaii from spreading to the mainland. This work is conducted jointly, under Federal supervision, with representatives of the Territorial government. All aircraft arriving in the Territory and surface vessels arriving in Pearl Harbor from the mainland are now inspected by Federal personnel in the enforcement of Quarantine No. 51. This work was formerly performed by the Territorial personnel. All aircraft from abroad are now disinsectized for agricultural pests on arrival in Hawaii. Advantage is taken of the strategic geographic position in Hawaii, which causes aircraft from over the Pacific to funnel through the Territory before proceeding nonstop to the mainland. Inspection at Hawaii of aircraft departing for the mainland removes pest risk at or nearer its origin and also saves manpower on the mainland.

The foreign-plant-quarantine operations and mainland-to-Hawaii inspections have been summarized elsewhere in this report. A total of 5,007 aircraft departing for the mainland were inspected in 1947, as compared with 9,047 in 1946, the decrease being due largely to the decrease in military movements. The number of planes found with unauthorized plant material increased from 1,022 in 1946 to 1,412 in 1947. The number of pieces of air-borne baggage examined was 131,700. The pieces of surface-borne baggage and auto trunks inspected and sealed prior to departure for the mainland rose from 699 in 1946 to 10,470 in 1947. Examination of express for the mainland included 17,882 pieces, of which 2,710 were opened and inspected. Inspection of parcel post for the mainland included 75,231 parcels opened and inspected out of 376,188 parcels handled. Plant quarantine control of fruit and vegetable movement to the mainland required the certification after inspection of 2,686 shipments and the certification of 89 shipments after the supervision of 35 treatments required as a condition for certification. Examinations of leis and other cut flowers totaled 61,869 packages, of which 59,493 were passed and the remainder rejected for pest-risk reasons.

Puerto Rico, like Hawaii, is a strategic plant-quarantine outpost. In cooperation with insular inspectors the plant-quarantine activities of the two islands are conducted along similar lines as far as is practicable. A study was made of the desirability of preflight examination of aircraft departing for nonstop flights to the mainland, but as neither adequate facilities at the airport nor the required personnel

were available, the inauguration of this desirable plant-quarantine measure had to be postponed. A total of 299 shipments of vegetables moved to the mainland in accordance with Quarantine No. 58. Parcel-post packages examined before departure for the mainland totaled 108,095, of which 11,431 were opened and inspected.

PLANT MATERIAL IMPORTED FOR SCIENTIFIC AND EXPERIMENTAL PURPOSES

A total of 469 shipments of plant material imported by the Department of Agriculture for scientific and experimental purposes, were examined during the year, and treated if necessary, at the Washington, D. C., inspection house. These exotic plants are grown for a period in detention under quarantine conditions by the Department and inspected frequently to determine whether any pests are present which were not eliminated at the time of entry. Such plants and their progeny are not released for distribution or propagation until they have been determined to be apparently pest free. Final inspection prior to dispatch was made of 2,273 outgoing shipments of departmental plant material in this category.

Plant material that is being propagated at plant-introduction and propagating gardens maintained by the Bureau of Plant Industry, Soils, and Agricultural Engineering is inspected regularly for the presence of plant pests. Such material distributed from the gardens at Coconut Grove, Fla., and Mandan, N. Dak., was inspected by State officials cooperating with this Bureau. The inspections at Chico, Calif., were handled jointly by an inspector from this Bureau and an entomologist from the California Department of Agriculture. Material distributed from the District of Columbia, Maryland, and Savannah, Ga., stations was examined by Bureau inspectors. The following were examined prior to distribution from the stations of the Bureau of Plant Industry, Soils, and Agricultural Engineering during 1947: 152,000 plants, 5,062 bud sticks and cuttings, 66,136 roots and tubers, and 2,189 shipments of seeds.

INCREASED INTERCEPTIONS OF PROHIBITED AND RESTRICTED PLANTS AND PLANT PRODUCTS

There was an increase of 23 percent over 1946, in the interceptions of prohibited and restricted plants and plant products. The totals were as follows: In baggage, 90,810; in cargo, 1,602; in mail, 3,176; in quarters, 9,410; in stores, 15,596; total, 120,594. Additional interceptions were made by customs officers at Canadian and Mexican border ports where traffic conditions do not warrant the services of a plant-quarantine inspector.

The excellent cooperation of other Government agencies, particularly the Customs, Immigration, and U. S. Public Health Services, in the enforcement of foreign plant quarantines, has been of great assistance to this Bureau in preventing the entry of pests. The Army and Navy continued to contribute to this program by issuing directives and employing safeguards to prevent the entry of potential pest-carrying material by troops and with military equipment returned from theaters of operations.

FOREIGN PESTS PREVENTED ENTRY

During inspection of foreign plants and plant products, together with similar importations received on the mainland from Hawaii and Puerto Rico, inspectors and collaborators of the Bureau collected in-

sects belonging to 1,408 recognized species distributed among 1,120 genera and families, as well as fungi, bacteria, nematodes, viruses, and algae belonging to 381 recognized species, and large numbers of pathogens that could be referred to genus, family, or general group only. Other intercepted pests were primarily of scientific interest, including a number of undescribed species not heretofore represented in the Department's collections.

The combined total of 65,004 interceptions of insects and diseases were taken as follows (figures refer to number of interceptions):

	Insects	*Diseases*
In material offered for entry:		
For consumption	26,197	14,979
For propagation	13,620	4,378
In material in transit, in ship's stores, quarters, etc	3,862	1,968
Total	43,679	21,325

SANITARY INSPECTION AND CERTIFICATION FOR EXPORT

A total of 5,822 export certificates covering 1,983,961 containers were issued on the basis of inspections to meet the sanitary requirements of foreign countries, representing increases of 52 and 34 percent, respectively, over 1946. Certificates were issued at 39 ports covering 70 commodities which were exported to 88 foreign countries.

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